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THE THIRD CONFERENCE OF THE TEA RESEARCH INSTITUTE OF CEYLON

The Third Conference of the Tea Research Institute of Ceylon was held at St. Coombs on January 27th, 1933.

MORNING SESSION.

Chairman.—Mr. A. G. Baynham, M.C., B.A., Chairman, Planters' Association of Ceylon.

THE CHAIRMAN'S ADDRESS

Gentlemen: It is not my intention to presume upon my temporary occupation of this chair by inflicting upon you a lengthy inaugural address and so delaying the real business of the day, but there are a few observations which might be made by way of introduction.

In the first place it is my privilege to welcome all those who have come to attend this Conference, the third to be held under the auspices of the T. R. I., and secondly, I must express my appreciation to Dr. Norris and the members of the Board for having done me the honour of asking me to preside during the morning session. I interpret this request as a tribute to the close relationship which has always subsisted between the T. R. I. and the P. A. of Ceylon, and am glad that we, on our part, have been able to make a contribution towards reducing the administrative expenses of the Institute at a time when economies have become a matter of urgent necessity in every department.

As you are probably all aware, the T. R. I. cess is due to be reduced in 1934 from 14 cents to 10 cents per 100 pounds of tea exported, and, in addition to this, restriction will involve a further loss of income from this source amounting to 15 per cent. The financial position is, in fact, causing considerable anxiety and it will be understood that not only must any expansion of the Institute's activities await better times, but, if present conditions continue for any lengthy period, it may be a matter of difficulty to maintain the existing programme. Fortunately, it is not necessary to take an immediate decision on this problem, and it is to be hoped that the position may yet be eased by an improvement in the revenue from the estate, but one or two points need emphasis in order to

remove any possible misapprehension which may be aroused in the minds of subscribers. The first is that there has been no over-expenditure on the estimate included in the forecast submitted to Government in 1930; it is, in fact, estimated that over the five year period, 1930 to 1934 inclusive, there will be a nett saving on capital and revenue account expenditure of Rs. 55,000, even if full provision is made for the completion of the building programme. Actually the latter cannot be taken in hand, and the sum allowed for under this head, approximately Rs. 70,000, will have to be utilised for ordinary running expenses.

It will, therefore, be readily understood that the explanation must be sought on the revenue side of our account which consists of two items—nett sales of tea produced on St. Coombs, and the proceeds of the cess.

As regards the former, the forecast was based on what appeared in 1930 a conservative valuation for quality Dimbula teas, and this is demonstrated by the fact that the receipts were Rs. 8,500 in excess of the estimate for that year. The history of the decline, in the tea market since that date is well known to all of us; it will have resulted in a total shortfall of Rs. 167,918 over this five-year period unless the revised estimate for 1933 and 1934 proves to be unduly pessimistic.

So far as the cess is concerned, this will probably produce some Rs. 45,000 more than was expected when the forecast was framed, in spite of the fact that the Island's crop is likely to be restricted during the next two years by 15 per cent. But, none the less, restriction will result in a very material decrease of revenue for the Institute from this source. For this reason it is most earnestly to be hoped that the Board appointed to control the regulation of tea exports will recognise the insistent claim of St. Coombs for exemption from what will amount, in this case, to nothing less than double taxation.

Doubtless there will be many hard cases to consider; this Institute, however, is an integral part of the Tea Industry of Ceylon, which restriction is designed to assist, and it is likely to prove a last line of defence in the industry's struggle for survival wherein, as in the Great War of 1914-18, the scientist may be called upon to play a predominating part.

We have complete confidence in the ability of Dr. Norris and his staff to provide that expert assistance which we require, and

have reason to be deeply indebted to them for their loyalty in voluntarily submitting to a cut in their salaries, which will result in a saving to the Institute of over Rs. 9,000 per annum. Their position, like that of the members of the Public Services, is somewhat different from ours, and for that reason the sacrifice which they have made has a very special significance, which even the most impoverished planter, who may have come to regard successive cuts in salary as an inevitable feature of present day conditions, will readily and cordially acknowledge.

With these few words, gentlemen, I have pleasure in declaring this Conference duly open and will call upon Dr. Norris to review the Institution's programme.

REVIEW OF THE INSTITUTE'S ACTIVITIES

ROLAND V. NORRIS, DIRECTOR

Mr. Chairman and Gentlemen, when addressing you on the occasion of the Institute's last Conference held two years ago just after we had started work at St. Coombs, I indicated various lines along which we hoped to develop our work and you will naturally expect to hear during the present Conference how far these expectations have been realised and what results have been achieved in some of our major investigations.

The expansion in our experimental programme which naturally followed the move to St. Coombs has necessitated a considerable increase in our staff, and the latter now includes, besides the seven senior officers, fifteen assistants. Of the latter, ten are working at headquarters and five in outstations, namely three in Passara, one at Galatura in the Ratnapura district and one in the Gampola area. No further increase in staff is contemplated in the near future, for not only are we not in a position to finance further capital expenditure on quarters but our recurring expenditure is now at a figure which cannot safely be increased until our general financial position is more assured.

Mr. Baynham in his opening remarks has referred to our finances and I think it is desirable that I should enlarge a little on what he has said, as it is clear that any developments contemplated in the immediate future are entirely contingent on our income being maintained at a reasonable and fairly assured level. Before proceeding further, however, I must acknowledge the way in which we

have been met by the Planters' Association who have agreed to a reduction in our subsidy of Rs. 3,600 per annum.

Referring first of all to the year that has just closed, St. Coombs, in common with estates all over the Island, has suffered severely from the general fall in tea prices. I shall refer to certain technical aspects of this fall in tea prices later in my remarks but, whatever the cause may be, the result is that our receipts from tea sales have fallen short by a very considerable sum of our reasonable anticipations. This deficit has been partially covered by increased receipts from the export cess and the balance has been met by very considerable economies which have been effected in every department of our work both on the estate and research sides, with the result that our carry forward will, I believe, not fall short of that shown in our estimates for the year. That is satisfactory so far as it goes but it is the future position which is causing us very real anxiety. Our income, as you know, is derived entirely from our tea sales and from the export cess. In regard to the former it would be unwise to count on any rapid rise in prices, though we all hope the disastrous figures of last year will not be repeated. In regard to the cess we are faced with a period of restricted exports which will automatically bring about in our income for the present year a drop of some fifty thousand rupees, while in the following year we shall have a still further drop due to the fact that the cess will then be on a 10 cents basis instead of 14 as at present. Nor is that the whole story. Unless exemption is granted we shall under restriction not only lose the Rs. 50,000 already referred to but we shall by restriction of our own crop suffer a further decline in our receipts from our tea sales. The cumulative effect of these factors would be disastrous, and I do not see how under such conditions, the work of the Institute could be maintained on its present scale. In these circumstances, representations are being made that the Institute should be exempted from restriction of its own crop and I hope these representations will receive the strongest and most active support from all those in this room today. We must ask ourselves—is this the time when research can wisely be relaxed? To my mind there is only one answer to that question, and that is an emphatic negative. It is surely at a time like the present, when the necessity for maintaining and improving the quality of Ceylon teas is assuming greater and greater importance, when, due to the curtailment or cessation of manuring, the industry is faced on all sides with the problem of how best to maintain soil fertility and preserve the capital value of estates, that research should

be intensified rather than relaxed and every effort made to find solutions to some of the problems that beset us in the shortest possible time. I believe the view I have expressed will receive your general support, and I have every hope that circumstances will not be permitted to arise which may necessitate any curtailment in the activities of the Institute and in the assistance which it can extend to you in your difficulties.

That the Institute can be of assistance is rapidly becoming more widely recognised and I am glad to think that many of those who at first were sceptical or even worse are now amongst our strongest supporters. In the past year 245 visits have been made to estates by members of the staff as compared with 131 in 1931, while the number of general enquiries which have been dealt with by correspondence has increased on much the same scale and amounted to more than 2,000 during the year. We have very definite evidence that the advice so tendered has been of service to Superintendents, and I venture to make the claim that the Institute has already justified its existence, while, at the same time, remarking that the extent to which we can be of assistance depends very largely on the readiness of Superintendents to take advantage of the facilities available. We are anxious to increase our contact with the planter to the fullest possible extent and in this connection I would mention that it would in my opinion be helpful, if members of the staff had more frequent opportunities of attending meetings of your District Associations, not simply for the purpose of giving formal lectures, though these will be arranged when desired if reasonable notice be given, but even more for the opportunity it would afford for informal discussions of the problems and difficulties which are continually arising in the running of your estates. Similar advantages would be gained from more frequent visits by planters to St. Coombs. Here I must say a word about Visitors' Day which as you know is the first Wednesday in each month. I have come across a few people who are suspicious of Visitors' Day and imagine that a certain amount of window dressing takes place on such occasions and that they will not see the Institute under normal working conditions. This, of course, is quite an erroneous belief and the idea of having specific days for visitors is simply to avoid undue interruption in the work of the staff, with the added advantages that on these days all members of the staff are at headquarters and a visitor can, therefore, be sure of finding the appropriate officer to deal with his enquiries.

Passing on to more technical matters I should like to say something about manufacture. The condition of the tea market has naturally stimulated interest in manufacture and a very large number of enquiries have been dealt with on this subject. Sixty-five estate factories have been visited during the year, while the number of tea samples sent in for examination exceeded 1,800. In this connection I must stress the fact that the Institute cannot undertake ordinary tea tasting which can be much more effectively carried out by your own brokers.

The visits which Dr. Evans has made to estate factories has shown that certain difficulties are of general occurrence and he will deal with some of these in his paper this afternoon. I will not therefore enlarge on these at the moment but merely say that there is ample scope for improved design not only of individual machines such as driers or sifters, but in general factory layout. Ceylon factories are on the average no doubt better equipped than, and as well kept as, those elsewhere, but under present practice there is far too much handling and trampling of leaf. This is not only uneconomical in labour but undesirable on hygienic grounds and I cannot but feel that unless matters are improved in this respect, public opinion will at no distant date demand greater attention to these points. It is a subject which might well receive attention from engineering firms dealing with tea machinery.

During the year we have completed the installation of our small scale machinery which now comprises four rollers, two sifters, two driers and a number of withering tats. The expenditure on this amount has been met from a grant kindly made by the Empire Marketing Board. Some people perhaps think that these machines are mere toys and not of great value from a practical point of view. This, however, is not the case. Without this plant it would be impossible for us to push our field experiments to their logical conclusion by testing the influence of the treatment under investigation on the quality of the made tea. Leaf from the manurial and pruning plots is regularly manufactured on these machines and the samples sent to Colombo brokers for report and valuation. I must take this opportunity to say how very much we are indebted to these gentlemen who have examined several hundred samples. The reports are invaluable and a most important part of the experiment.

The small scale plant, however, has not only been used for leaf from experimental plots. On the contrary, a large range of experiments has been carried out on these machines, covering all phases

of manufacture. Useful indications are obtained in this way which can then be tested out on the full scale plant.

I have already referred to the fall in our tea prices during the non-flavoury season. Apart from the general fall in tea values, I think this can largely be explained by the very marked insistence on coloury liquors during the off-season, colour being demanded almost regardless of other considerations. It became clear, therefore, that some modification in our normal manufacture would be required. To meet this demand and also recognising the importance of factory experiments in general on as wide a scale as possible, the Board decided in the middle of the year that no distinction should be made between the commercial and research sides of the factory, but that the commercial plant also should be utilised to the full for experimental purposes. In other words the whole factory has been placed on an experimental basis. It is not, of course, difficult within limits to produce more coloury liquors, the trouble is that those methods which tend to produce colour also tend to diminish pungency and quality. At certain seasons of the year, or at certain elevations, it will be a matter for decision, therefore, as to which factor is most in demand and manufacture must be modified accordingly. There is, I am afraid, far too great a tendency on many estates to try and standardise manufacture throughout the year regardless of climatic variations and market conditions. This is obviously unsound. Greater liaison is required between the producer and the market, and I think in this direction more assistance could be given to superintendents by brokers if some more satisfactory basis of reporting on tea samples could be worked out. It should be possible for the Superintendent in this way to receive more implicit indications as to the intrinsic properties of his teas and some guidance as to which of these could be most profitably developed under any given market conditions.

So far as the Institute is concerned some steps have already been taken towards developing such liaison. One conference has already been held between members of the Staff and representative brokers and buyers in Colombo, and a second meeting of the same nature is to be held early next month.

Before passing on to indicate probable developments in our work on manufacture I must refer to one circumstance which will, I know, be received with very wide regret. I refer to the impending departure of Dr. Evans who has resigned his appointment with

the Institute and will be leaving Ceylon in April. Dr. Evans has been with the Institute for over six years and during that time has done work of the highest service to the tea industry in Ceylon. The value of this work has, I am glad to say, been widely recognised by Planters and I feel you will all wish to join with me in expressing to Dr. Evans our appreciation of his services and in wishing him all success in the new career he hopes to make at home.

Consequent on Dr. Evans' resignation certain changes will be made in the organisation of the Biochemical section. This section will on my return from leave be under my direct charge and I shall myself take over the laboratory research involved. To replace Dr. Evans, an officer, whom I may best describe as a Tea Technologist, will be appointed, who will devote his whole time to experimental manufacture and advisory work on this subject. There must necessarily be some delay before this officer can reach Ceylon and while he is acquiring experience of manufacturing conditions, and it is most unfortunate that an interregnum of this kind should occur at a time like the present. Eventually however I think the reorganisation contemplated will enable us to give greater assistance in manufacture than is now feasible. With a whole-time officer on this work it will, I hope, be possible for manufacturing experiments to be conducted not only at St. Coombs but also in other factories out in the districts. I feel sure that such a development will be welcomed, particularly by planters in the Low and Mid-Country, and I have no doubt necessary facilities will be placed at our disposal.

We have seen during the year the introduction of new types of machinery such as the C.T.C. roller and the Legg Cutter. Whatever the results obtained in India, our observations on the working of these machines in Ceylon have so far failed to give any indication that they will fulfil the claims made. The Marshall-Boustead chilled roller seems to me to have greater promise but I believe this has so far only been tried out in one factory and further experience is desirable of its working under different conditions.

As envisaged in my remarks two years ago very considerable expansion has taken place in our field experiments. In addition to the manurial experiment which has now completed its second year and which will be discussed this morning, pruning experiments designed to compare the effect of different types of pruning have been begun at St. Coombs, Peradeniya and Galatura, and I must here express our indebtedness to the Director of Agriculture and his

staff and to the Agents and Superintendent of Galatura for the facilities which have been placed at our disposal. At St. Coombs the effect of time of pruning is also under investigation and the total area under pruning experiments is rather more than eight acres. I believe the results of these experiments are of the highest practical importance and you will hear of these during the Conference. The Plant Physiologist has also begun an examination of different tea jâts and a considerable number of strains, including four races of Formosa Oolong tea, have been collected and planted out. In this connection I must refer to the proposal made in the 18th Report of the Imperial Economic Committee that genetical work on tea should be carried out. It is unlikely in my opinion, in our present state of knowledge, and particularly as we have no means of testing for quality in the early stages of growth, that seed selection will lead to practical results in any reasonable period of time. On the other hand the vegetative propagation of tea does, I think, merit attention. Propagation by layering is common practice in Formosa and, in spite of its cost, is considered worth while, in that the characteristics of their jâts are maintained. The subject is therefore under investigation.

Considerably increased provision has been made in our estimates for the current year for work on cover crops and green manures and the number of varieties under trial will be materially increased. In this work we can receive considerable help if planters will send us for trial seeds or cuttings of cover crops or green manures which have been tried on their own estates. In case of leguminous crops the difficulty in establishing some varieties may possibly be due to the absence of the appropriate organisms in the soil. This subject is under investigation by the Mycologist and if this surmise should prove correct it should be possible to devise means to overcome this difficulty.

Pests and diseases have fortunately not been prominent during the past year and time will not permit me to say much about them.

A small sub-station has been maintained in the Passara area for work on Nettle Grub which I am glad to say has been much less in evidence this year.

Work on the breeding of the Tortrix parasite has made much progress and we are only awaiting the arrival of Tortrix in sufficient numbers for a field trial to be made of this method of control.

It is unfortunate that, owing to the lack of suitable trees and facilities for nesting, birds are usually scarce on tea estates. The

encouraging of certain species of insectivorous birds by the provision of nesting facilities might well do much to keep down insects and the subject is under investigation.

Witches Broom continues to be a source of anxiety as the cause of this is still quite obscure and no certain remedy is known. It is almost certain, however, that the term covers more than one disease. In some cases, as happened in Kandapola early last year, the disease clears up spontaneously as soon as favourable conditions of growth recur. In other cases the disease gets progressively worse and no treatment seems of much utility. A somewhat similar disease, known as Tea Yellows, occurs in Nyasaland and is there attributed to deficiency of sulphur in the soil. In view of the results obtained there, experiments are in progress to ascertain whether Witches Broom is due to a similar cause. At the moment this seems rather unlikely but it is too early to give a definite opinion.

In conclusion, I must refer to one other development of our work, namely work on small-holdings in tea. There are some 7,500 small-holdings in the Island comprising about 35,000 acres. A Small-holdings Officer was appointed in October last and is now working in the Gampola-Peradeniya-Kadugannawa area. Improvement in such holdings is difficult owing to their small size and to the economic position of the owners. The response to the work of the Small-Holdings Officer has, however, been striking. A considerable number of small-holders are working their lands under his guidance and these will form demonstration plots from which other holders will see that considerable improvements can be effected in soil treatment, plucking, pruning, etc., without undue expenses. A demonstration plot run by the Institute will shortly be started and by means of lectures, leaflets and other propaganda work the small-holder will be encouraged in every way to improve the condition of his holdings with benefit not only to himself but to the industry as a whole.

I am aware there are a certain number of persons who consider that we should work in an atmosphere of secrecy, and who rather deprecate association with other Research Institutes. I must confess I find myself in profound disagreement with this view. Personally I consider we have everything to gain by the closest co-operation with other Institutes working on tea and I do not confine myself to Empire Stations, but include the stations in the Dutch East Indies and elsewhere. We have, after all, as much to gain as to give and

the most rapid progress is likely to be achieved by the fullest measure of co-operation. In this connection I should like to see a deputation from Ceylon, including representatives of the T. R. I., of practical planters and Colombo business interests sent to Java to see the methods in vogue there. I am assured such a deputation would receive a warm welcome and be given every facility to study conditions there. I believe such a visit would remove many misconceptions and be of general benefit to us all.

RECOVERY FROM PRUNING

F. R. TUBBS

At the last Tea Conference held in February, 1931, I described the general problems that present themselves when pruning is considered from a scientific point of view and indicated the applications of the knowledge gained from other crops to the special case of the tea bush.

The tea bush, as grown in Ceylon, is unique when compared with other crops, being a small evergreen tree, growing throughout the year without definite resting seasons, and for economic reasons maintained as a small bush from which its young shoots are persistently removed. Fodder plants are a case in which young growth is steadily removed, but neither they nor, on the other hand, evergreen fruits such as citrus, can be directly compared with tea. It follows, therefore, that investigations on the tea bush must start *de novo*, and while the general considerations previously described to you are an aid in prophesying probabilities, direct experiment alone can provide the particular data that are necessary if the bush, and therefore the tea industry, is to be maintained in a healthy condition.

Pruning of tea is performed under the widely varying climatic conditions associated with different parts of the Island, at all times in the year, and in many different ways. The examination of the problems was taken up in a way that provides information upon the effects of different types of pruning done at various elevations and at three climatic seasons.

The three types of pruning chosen were clean pruning, rim lung pruning, and cut across pruning. It is not suggested that these types are entirely distinct. Variations of one type lead imperceptibly to another type, as is illustrated in Plate I. You will see that a normal clean pruned bush leads via a bush in which a fringe of small

branches is left to a rim lung type of bush in which several large branches are left unpruned. By leaving the fringe and increasing the number of pruned points that are left within the bush, we proceed towards the cut across bush in which nothing save diseased wood is removed below the pruning level. If a type of pruning similar to a cut across is done several inches higher in the bush, about $\frac{1}{2}$ an inch above the tipping level of the previous cycle, the type of pruning which has been called "travancore" is obtained. If this is cleaned out, we reach a very high type of clean pruning. It is obvious therefore that it is entirely impossible to test every type of pruning, but it is feasible to select distinct types in the circle of possible types and from a knowledge of those tested the probable behaviour of the intermediate stages can be prophesied.

The three types of pruning used may be described as follows:—

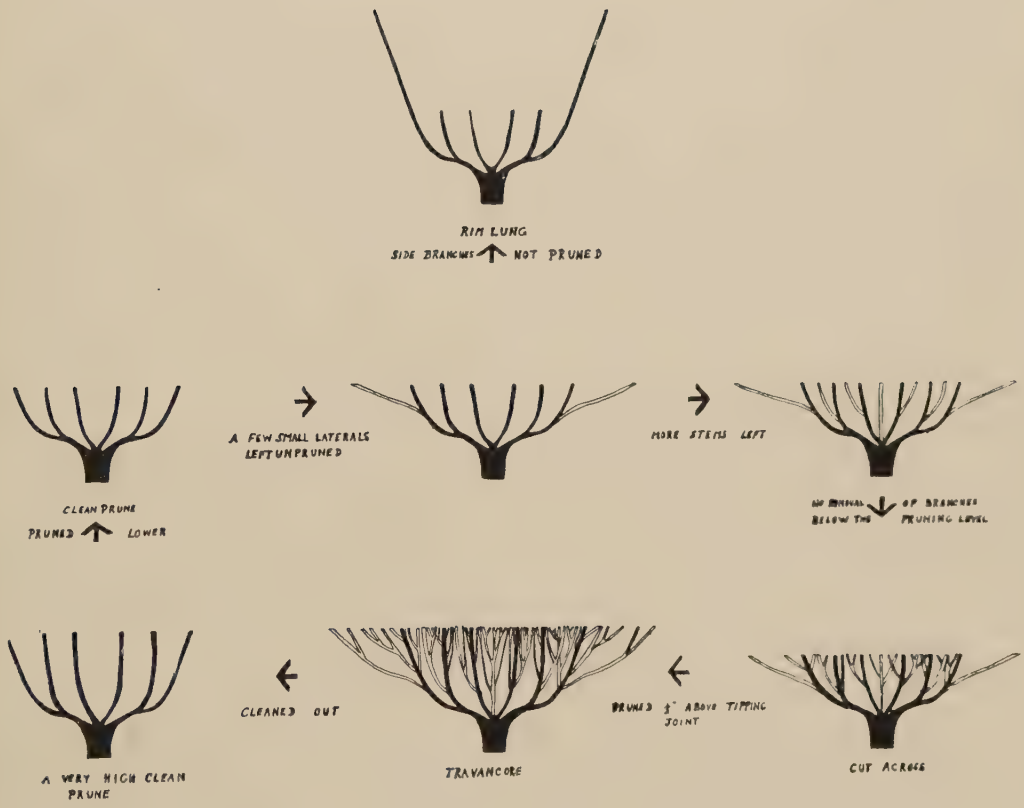
(a). Clean prune. The main frame forming branches were cut to three inches above the previous pruning level, nearly all of the smaller branches being removed;

(b). Cut across pruning at the same level, nothing save diseased wood being removed below the pruning level;

(c). Rim lung pruning at the same level as the other two types, the centre of the bush being clean pruned and six branches on the circumference being left as lungs until about ten days before tipping.

As has already been stated in our publications these three types were tested at St. Coombs on $4\frac{1}{2}$ acres of tea, all three being repeated at three times, namely, the end of August, 1931, the end of December, 1931, and the end of April, 1932. In addition the effect of elevation has been examined by means of experiments pruned at the end of April, 1932, at Galatura near Ratnapura at an elevation of 200 feet, and at Peradeniya near Kandy at an elevation of 1,500 feet above sea level, each of $1\frac{1}{2}$ acres extent. These experiments have only been rendered possible by the co-operation with the Tea Research Institute, of Messrs. James Finlay & Co., Ltd., and the Amalgamated Tea Estates Co., at Galatura, and of the Department of Agriculture at Peradeniya.

Pruning is peculiarly a problem, or rather a series of problems, which require different answers at different elevations and in different districts, a fact that will be obvious from the data to be described



THE INTER-RELATION OF PRUNING TYPES.

later in this paper. It is essential that influence of varying environments found in different parts of the Island should be adequately investigated, and I feel sure you will all completely realise the debt owed by the Tea Research Institute and through them by the tea industry to these bodies for their aid in obtaining more widely established information than would otherwise be possible. Today I propose to discuss some of the earlier results obtained from these experiments together with other information that has been garnered since the Conference of 1931 upon the subject of recovery from pruning. The effects of the method of pruning employed, the time at which the operation is performed, and the elevation of the estate upon the bush and upon recovery from pruning will be dealt with. I do not doubt that many would have been glad to have seen this subject extended to cover the subject of yield, but it will be realised that any remark upon yield can only be in the nature of a shot in the dark at present and would certainly be out of place in this discussion today.

TABLE I

Branch Numbers and Branch Thicknesses.

Type of Pruning.	Height of pruning above ground level in inches.	Total number of branches at pruning level.	Average thickness at the pruning level in c.m.
Travancore	19	229	0·47
Cut Across	17	157	0·62
Clean Prune	17	23	1·21
Severe Clean Prune	9	11	2·80
Collar Prune	0	1	12·45

Table I gives the effect of pruning at different heights above ground level and in different ways upon the number of branches at the pruning level and the average thickness of wood cut into of a representative tea bush. Reduction of the height of the cutting across from 19 inches to 17 inches causes an increase in the thickness of wood cut into, and a reduction in the number of branches pruned. The removal of the smaller branches increases this effect, which is still further heightened by lower clean pruning. It is noteworthy that the quickest recovery is shown by those types in which most thin young wood remains, a travancore at low elevations being normally in plucking six weeks after pruning. Variations in pruning also cause large differences in the amount of leaf and wood

removed from the bush as is obvious from an inspection of Table II in which the material removed by travancoring, cutting across and clean pruning is expressed as a percentage of the total weight of leaves and branches. The total material removed per acre by clean

TABLE II

Material removed by Pruning.

Type of Pruning.	Percentage weight of leaves removed.	Percentage weight of branches removed.	Percentage weight of leaves and branches removed.
Travancore	90	32	42
Cut Across	95	39	49
Clean Prune	100	50	59

pruning in this case was about 2,000 pounds dry weight of leaf and 10,000 lbs. dry weight of branches. A further experiment showed that the effect of type of pruning upon the weight of leaf remaining on the bush was most marked. Rim lung pruning had the most leaf, followed by travancore which in turn was followed by cut across, clean prune having no leaves at all. The differences between the types were significant and it is important to note in connection with the pruning of fields suffering from starch deficiency, that comparatively severe cleaning out of the centre of the bush accompanied by the provision of adequate lungs results in more leaf being left on the bush during the critical period of recovery from pruning than does what is normally considered a much "lighter" type

TABLE III

Diameters of Pruned Bushes.

Clean Prune.	Cut Across.	Rim Lung.
2·7 feet	3·3 feet.	3·5 feet.

of pruning, e.g., travancoring. The type of pruning used also influences the diameter of the pruned bush, (Table III), clean pruning causing a significant reduction of diameter compared to other methods owing to the removal of all the thin lateral growths.

We have now gained a little information upon the physical effects of pruning upon the bush and may turn our attention to the effects of the wound-stimulus that has been applied. In order that new growth may be produced mobilisation of food reserves and their

transference together with the material manufactured by the leaves that remain after pruning (if any) to the potential growing point is essential. If a method of pruning involving the removal of nearly the whole of the leaves is used, recovery is almost entirely dependent upon the reserves present within the bush at the end of the previous cycle. If these are insufficient, bushes die either completely or partially thereby causing loss both of capital and of revenue to the estate. Deficiency of reserves is rare above three thousand feet but below that elevation its presence may have serious results and its relation to pruning methods is important. It was found at Galatura at an elevation of 200 feet, that the number of deaths after clean pruning was significantly greater than the number after rim lung or cut across pruning. The latter two did not differ significantly. As

TABLE IV

	Clean Prune.	Rim Lung.	Cut Across.	Mean.	Standard Error.
No. of deaths in three months in 1,500 bushes.	67	27	8	34	7·96
Percentage of mean.	197·1	79·4	23·5	100	23·4

will be seen from Table IV clean pruning resulted in the death of 67 out of 1,500 bushes, or four and a half per cent, after pruning. This may not seem very large, but when it is realised that this occurred on an area of tea specially selected for uniformity and therefore for healthiness, it will be appreciated that it may, and indeed does become very serious on areas impoverished by poor soil or by the attacks of pests. It will be noted that the standard error of the results was high. This is due entirely to the fact that the plan of the experiment was more suited to the collection of yield data replicated in time than to estimates of deaths after pruning, but the high error in no way affects the validity of the conclusion I have drawn.

TABLE V

Dieback after Pruning in different blocks at Galatura.

Blocks.	G	H	I	J	K	L
Weight of dieback.	160	180	125	81	85	72
Dry weight of material removed from the bush in 1st tipping lbs.	13·99	14·20	18·70	20·56	20·10	23·65

TABLE VI

Dieback after pruning at Galatura.

	Clean Prune.	Rim Lung.	Cut Across.	Mean.	Standard Error.
Pounds of dead material from 1,500 bushes.	346	130	227	234	22·7
Do. as percentage of general mean.	147·6	55·5	96·7	100	9·7

TABLE VII

Number of Leaves remaining after pruning at Galatura.

Clean Prune.	Cut Across.	Rim Lung.
3	42	201

Deficiency in reserves does not necessarily result in the death of entire bushes. Table VI shows that in addition to the four and a half per cent of deaths caused by clean pruning, 692 lbs. per acre of dead branches were removed from the clean pruned area by a careful secondary prune three months afterwards. This amount is significantly greater than that occurring after rim lung or cut across pruning. Rim lung pruned plots gave 260 pounds of dead wood per acre, compared to the 454 pounds on cut across plots. The least dieback resulted from rim lung pruning and the most from clean pruning, with cut across occupying the intermediate position. It has been frequently emphasised in the publications of the Institute that in cases where there is a deficiency of food reserves in the bush at the end of the cycle, it is important to adopt a style of pruning which will leave sufficient leaf area upon the pruned frame to manufacture the material necessary for the production of new shoots and leaves from the pruned frame. It is interesting to note that the average number of leaves on a pruned bush in rim lung plots was 201, compared to 42 on a cut across bush and 3 on a clean pruned bush. The importance of ensuring that leaves remain on the frame during recovery from pruning has now been abundantly demonstrated.

It is also of interest to note that the figures in Table V indicate a strong negative correlation between tipping growth removed and the amount of dieback. Two factors probably enter into this result, firstly dieback will reduce the number of shoots coming into tipping and secondly dieback may be associated with fertility of the soil.

This presumption is strengthened by the fact that seven months after pruning, the yield of flush shows a strong negative correlation with dieback similar to that shown in Table V, the high-yielding plots being those in which little dieback had occurred previously.

The production of new shoots is dependent upon jât, environmental factors and the type of pruning used. We shall now proceed to complete the survey of recovery from pruning by examining the effect of these factors upon the growth rate up to the end of the third tipping.

Pruned tea does not become ready for tipping at equal times from pruning at different elevations or under different systems of pruning. If it was possible to estimate by mere visual inspection, the exact time when an area of tea would yield a given amount of tipping material, the time between pruning and tipping would provide an index of growth rate. But by actual experience, in other crops as well as in tea, visual inspection has been found useless in estimating yield. It follows therefore that in spite of every care in the selection of the tipping date, variations in yield will be found between different plots. To provide an index of the rate of growth after pruning, the dry weight of all the material removed from the bushes in the three tipping operations per plot divided by the number of days from pruning to third tipping has been selected. The figures in Tables VIII to XII are obtained in this way. It may be suggested quite correctly, that this ratio is not a complete measure of the growth rate, since only the new growth produced above the level of four and a half inches above the pruning level is considered The amount neglected is, however, probably fairly constant and would not therefore affect the results to any great extent.

TABLE VIII

Effect of time of pruning at St. Coombs upon growth rate up to the end of third tipping —totals of 18 plots.

	Pruned at the end of :—				
	Aug. '31.	Dec. '31.	April '32.	Mean.	S. E.
Growth rate	2·601	2·773	2·646	2·673	·071
Growth rate as percentage of the mean.	97·3	103·7	99·0	100	2·67

An examination of Table VIII shows that pruning at different times has not produced any effect on the growth rate at St. Coombs

during the period under discussion. Differences of about 8 per cent would be significant but the largest difference only amount to 6·4 per cent.

TABLE IX

Effect of type of pruning at St. Coombs — Totals of 18 plots.

	Clean.	Rim Lung.	Cut Across.	Mean.	S. E.
Growth rate.	2·416	2·361	3·243	2·673	·071
Growth rate as percentage of the mean.	90·4	88·3	121·3	100	2·67

A different state of affairs is found when Table IX is examined. The effect of type of pruning at St. Coombs is most marked. As before, differences of 8 per cent are significant and it will be observed that the cut across bushes have grown definitely more quickly than those pruned in other ways. The difference between the clean pruned and the rim lung pruned bushes is insignificant. The difference between the two is in all probability due to chance and it is very unlikely that there is any difference between them sufficiently large to be of economic importance.

From the data obtained up to the stage of third tipping at St. Coombs, we conclude that *time* of pruning has had no effect on rate of recovery, but that *type* of pruning has a large effect, due in the main to the quicker growth of cut across bushes.

Turning now to the effect of time of pruning on the relative efficacy of the three methods employed, we ask, is there any tendency for different types of pruning to cause the most rapid tipping growth at varying times of the year? Statistical analysis of the data shows that there is such a tendency. For example, in the August pruning the relative order was clean prune slowest, then rim lung and cut across fastest. In the April pruning, this was not the case, rim lung being the slowest of the three. This suggests that there may be good reason to vary the type of pruning with the time of year in which it is performed at St. Coombs. However I do not consider that this subject can be adequately dealt with until more complete yield records are available, but it is intended to examine the yield data, as soon as sufficient are available, with a view to the elucidation of this very important point.

The effect of elevation on the rate of production of new growth after pruning may be confused by the effect of jât differences. It

is well recognised that high jât bushes have "cleaner" frames than low jât bushes and it is interesting to note that the number of shoots produced by a high jât bush ready for tipping at Galatura is significantly smaller than is the case with the low mixed jât experimented upon at St. Coombs. Consequently a tipping field of high jât has less material to be broken back than one of low jât and, therefore, differences in the growth rate to time of tipping at different elevations have little meaning where jât of tea under experiment also varies at different elevations.

TABLE X

Effect of type of pruning at the end of April—St. Coombs Totals of 6 plots.

	Clean.	Rim Lung.	Cut Across.	Mean.	S. E.
Growth rate.	0·868	0·735	1·043	0·882	0·031
Growth rate as percentage of the mean.	98·4	83·3	118·3	100	3·51

TABLE XI

Effect of type of pruning at the end of April—Peradeniya Totals of 6 plots.

	Clean.	Rim Lung.	Cut Across.	Mean.	S. E.
Growth rate.	0·808	0·966	1·086	0·953	0·043
Growth rate as percentage of the mean.	84·8	101·4	114·0	100	4·51

TABLE XII

Effect of type of pruning at the end of April — Galatura. Totals of 6 plots.

	Clean.	Rim Lung.	Cut Across.	Mean.	S. E.
Growth rate	0·715	0·864	0·607	0·729	0·010
Growth rate as percentage of the mean.	98·91	118·87	83·3	100	1·37

It was found that marked differences existed between the effects of different types of pruning at the three centres of experiment as will be seen from Tables X, XI, & XII. In the April pruning at

St. Coombs the growth of rim lung bushes was the slowest, followed by clean prune bushes which in turn were slower than cut across bushes. At Peradeniya clean pruning resulted in the slowest growth, the cut across and rim lung pruned bushes not differing significantly in their rate of growth. Thus at Peradeniya the rim lung treatment results in growth which is faster relative to the other two treatments than at St. Coombs. At the lowest elevation, i.e., 200 feet, rim lung bushes are definitely the fastest. In Table XII you will see that the order is cut across slowest, clean prune next and rim lung fastest. Statistical analysis show that these results have a real significance and may therefore be relied upon. It is evident that the lower the elevation, the greater the value of rim lung pruning. By means of rim lung pruning one can perform all the bush sanitation required, without any of the disadvantages of clean pruning at low elevations, while in addition there is to be considered its valuable effect upon the spread of the bush.

Based upon these preliminary data I would suggest that where cleaning out of the bush and opportunity to perform sanitary operations on the bush are desired, clean pruning at high elevations be modified by leaving a lateral fringe in order that bush diameter is not reduced. At lower elevations clean pruning should be avoided and rim lung pruning substituted for it.

I have described today the results that have been obtained to date upon the subject of recovery from pruning. There are many problems that remain unsolved at the moment and indeed, the experiments already performed have raised in addition fresh problems which require elucidation.

We cannot hope to obtain a complete knowledge of the answers to all these questions in a short time, but as information is gained, and as soon as conclusions can be drawn, the material will be placed before the planting community.

DISCUSSION.

Mr. A. T. Sydney Smith said that he felt very diffident in initiating a discussion on the paper they had just listened to, for two reasons. Firstly, his mind, like the Chairman's, had lately been so concerned with the strangulating effects of the Minimum Wage Ordinance and other economic problems, that little time had been left to consider the best agricultural methods of growing tea. His second reason was that Mr. Tubbs had dealt with his subject in a complete and effective manner. It was difficult in the short time available to offer comment on many points so lucidly brought out.

He, personally had not expected such varying results from one type of pruning at different elevations. Such results showed the danger of drawing hasty conclusions from observations made in a restricted locality. In the old days, it took years to learn things and to improve a method, as they were dependent on the results of personal experience, slowly accumulated. Today, scientifically conducted experiments made for quicker and surer knowledge, and therein lay the utility of the T.R.I. in matters of research. Though Mr. Tubbs had said that we could only go very slowly, he considered that they would progress much more rapidly than ever before, because of the availability of research.

They had been given reasons for some conclusions which had taken them years to arrive at, for example the desirability of leaving leaves on the bushes at pruning time. When he first started planting, coolies were told to strip off all the old leaf. There was still a tendency for the cooly to do so, and it was surprising how hard it was to stop him.

There were certain aspects of pruning which Mr. Tubbs had not mentioned, doubtlessly because they opened too wide a field for discussion today. He referred particularly to the effects of the type of pruning on subsequent yield and on quality, the need or otherwise of a special pruning mixture, and the effect of such on recovery. These and many other points he would have liked to have heard more about, but it was evident that there was plenty for the T.R.I. to investigate still.

He asked Mr. Tubbs if his experiments were made on manured tea, and whether he would expect similar results on tea which had run out.

Connected with recovery from pruning was the important question of healing, which had not been touched upon. In that connection he emphasised the necessity for clean cuts and the removal of snags which, in the case of rubber, were known as "hat pegs".

Mr. Tubbs had not mentioned the effects of pruning on the root system. That was a very old "chestnut" with planters about which they still knew practically nothing. He hoped that before long Mr. Tubbs would tell them more about that subject.

Mr. Tubbs was a plant physiologist and therefore studied how plants grew. He was surprised that their main industry had not employed a physiologist long ago. There was a matter he wished to mention, namely Witches Broom, which was possibly a physiological condition of the tea bush and so would come within Mr. Tubbs sphere of work. It was not known what Witches Broom really was, and so possibly it could not be accurately described as a disease. It might be due to soil conditions or it might possibly be just a physiological condition. Anyhow, affected bushes got worse at each successive pruning. He specially commended its close observation to all planters as he saw it spreading in different districts and under different conditions. It called for

close observation because it was not conspicuous in its early stages; there was nothing spectacular about it to attract attention. It spread slowly and insiduously. It was about 12 years since he had first consulted Mr. Petch about it, but no remedy had yet been discovered and its cause and nature were still unknown. That made it all the more serious and called for team work from all for its investigation and the discovery of a remedy.

He apologised for digression as that might be his only opportunity of mentioning that subject at the Conference, and he felt that the attention of planters should be called to it, far more than had been done before.

Dieback was another serious matter. It was very common in the Low and Mid-Country though there was relatively little Up-Country. He had seen how alarming its incidence could be in the Low-Country at times and he realised how important was the type of pruning. It was generally recognised that light pruning was helpful and for that reason light pruning had become more generally adopted at lower elevations in recent years. There was no doubt that a pre-pruning rest also greatly helped. He thought that they had to thank Dr. Gadd for his assistance in finding that remedy, and for explaining the necessity for building up reserves of plant food to help recovery from pruning.

Even if it were possible he would not attempt to pull to pieces so excellent a paper, but he had no doubt whatever that that would be done in the good old planting way in the clubs and bungalows when they returned to the Districts after the Conference. The paper had given them much food for thought and it had warned them not to follow one another like sheep, because a method which suited a special case would not suit others equally well. It was evident especially as regards pruning that each elevation and each district and the requirements of each estate had to be considered on their own merits.

He thanked Mr. Tubbs for the interesting and engaging way in which he had treated his subject.

Mr. Tubbs stated that the pruning experiments at St. Coombs were started in August, 1931, on tea three years from the previous pruning, a manuring programme uniform for all treatments being adopted. The December 1931 and the April 1932 plots were respectively four and eight months older from pruning. All save the April plots were plucked up to the time of pruning. It was found that the leaf from the April plots was not worth manufacturing for the last four months before pruning, and consequently breaking back was practised periodically, to preserve a similitude of plucking until pruning time, and to avoid any disturbing effects upon the subsequent results due to a rest before pruning. The only way to have avoided this complication would have been to postpone the initiation of the actual experiment for three years, when it would have been possible to have done all the pruning on three-year-old wood. In order to start the work with the least possible delay, some plots had to run longer than the normal cycle.

The absence of any definite effects due to time of pruning was surprising. All that could be said was that the climatic changes in the period under discussion were not sufficient to produce differences of eight per cent in the results

at St. Coombs. In places where climatic changes were more marked, a measurable effect might occur in one cycle, but it was probable that under Dimbula climatic conditions, it would be necessary to prune for several cycles in the dry weather before measurable differences from monsoon pruned tea would be obtained. The effects of dry weather pruning were probably cumulative.

Mr. Sydney Smith had raised the questions of bush sanitation and wound healing. There was not time to survey all the aspects of pruning, but he supported him emphatically in his plea for the clean removal of snags. If snags were persistently left untouched, clean straight wood became in time practically non-existent and the pruning of the tea became a very difficult proposition.

It was worth while emphasising again that with rim-lung pruning all necessary bush sanitation could be performed, and while cleaning out the inside of the bush far more foliage could be left on the bush than was possible even by cutting across above the tipping level, i.e., by travancoring.

The effects of resting before pruning had been very effectively demonstrated at lower elevations. If restriction came in, as seemed very probable, he certainly considered that resting before pruning at elevations below three thousand feet was economically sound, as restriction could thereby be used to improve the health of the bushes. The effects of resting before pruning enabled bushes to survive which would not otherwise recover from the pruning operation. Resting after pruning could not help a dead bush to regain its life, but it found its practical uses in the beneficial effects it had upon the recovery of the frame. It had been found at St. Coombs that resting the bushes for four months after the normal tipping date resulted in an increase of 36 per cent in the weight per unit length of stem. That illustrated the advantage of resting after pruning from the point of view of frame renewal.

Dr. Cadd said that an outstanding point in Mr. Tubbs' paper was the eminent suitability of rim-lung pruning for low elevations. At the first Conference of the T.R.I. he had been able to offer an explanation of the cause of deaths after pruning and to suggest a remedy for that disease, known in the Low-Country as *Diplodia*. The necessity for a light type of pruning was then urged. At the second Conference, he had indicated that although light forms of pruning had reduced the incidence of *Diplodia* they had brought in their train other troubles connected with bush sanitation. Mr. Tubbs had that day given them details of a form of pruning which left a large proportion of leaf on the bush, and at the same time allowed of a thorough cleaning of the bush. He referred to the rim-lung pruning which had been demonstrated by experiment to be eminently suitable for Low-Country conditions. That type of pruning provided the two requisites that he considered essential for Low-Country tea, namely the leaving of sufficient foliage to enable the bush to carry on immediately after pruning, and an opportunity for cleaning out diseased branches from the bush. For those reasons he particularly commended that type of pruning to their attention.

The question of healing had been referred to by Mr. Sydney Smith, but in the speaker's opinion it appeared better to keep the question of healing somewhat apart from the problems of pruning. The ability to heal wounds appeared in some cases to be an inherent character of the bush. He had examined bushes growing side by side under identical conditions, pruned and cultivated similarly, yet one had healed all its wounds while the other showed no indication of healing at all.

With regard to Witches Broom he pointed out what a complicated problem that was. It was rather like a headache; one knew when he had got it and he might know the cause of it, but the cause was not always the same though the symptoms were similar. Witches Broom was a certain collection of symptoms not always brought about by the same cause. In one district, the disease occurred quite suddenly at the beginning of last year and it disappeared just as mysteriously towards middle of the year. In another case, he had seen a field due for pruning with all the symptoms of Witches Broom; it was pruned, and the field came back normally healthy. There were other fields which showed similar symptoms of Witches Broom but pruning those bushes merely accelerated their deaths.

As he had already said, in some cases the disease just disappeared; in others where the symptoms persisted the disease appeared to spread slowly but what was the agency of its spread he did not know. He had tried in every way he could think of, to infect healthy bushes with the disease but in every instance he had failed.

The Chairman thanked Mr. Tubbs for reading his paper and the members of the Conference for contributing to the discussion.

RECENT EXPERIMENTS IN MANURING OF TEA

T. EDEN.

INTRODUCTION.

In presenting at this Conference a paper on the results of the Institute's manurial trials, I am conscious that to some this may appear to be a discussion on a luxury that at the present time the industry can barely afford. It is however just this anxiety about manuring that has persuaded me to take up the subject; the practice of artificial manuring is not a passing phase in the development of the tea industry, it is a permanent feature, and I hold that a time when economic conditions are forcing estates to reconsider manurial programmes, is precisely the time when research should be vigorously prosecuted. If this is done it may be possible to eliminate wasteful expenditure and to provide fundamental knowledge on which to act when more normal conditions return.

Agricultural field experiments are not begun and ended in a day. Before setting out trials it is necessary to consider not only which of the many problems are of chief interest and importance at the moment, but to cast a prophetic eye into the future and decide which will remain important despite changes in conditions that may occur before the work reaches fruition.

Three aspects of manuring were much debated when the agricultural chemical division of this Institute was started. These were the response of tea to potash, the relative efficiency of inorganic and organic forms of artificial nitrogenous manures, and the question of manurial balance. The potash question is fundamental and no change of conditions can diminish its importance. The nitrogen problem is even more important now than when the experimental scheme was decided on; conceptions of balance in manuring are notoriously elastic even though the gross error of using single nutrients only is a thing of the past.

The experiments I propose to describe to you were accordingly designed to answer the following questions:—

1. What is the effect of increasing doses of nitrogen on tea?
2. What is the effect of increasing doses of potash?
3. What effect have these two nutrients on growth when considered together (i.e., the effect of balance)?

4. How do inorganic and organic nitrogen rank with respect to each other?

The question of phosphatic manures was reserved for later investigation.

METHOD OF APPROACHING THE PROBLEM.

Before describing in detail the results so far obtained from these experimental inquiries, I want to digress for a short while to consider the best means of providing sound answers, and to lay a few ghosts of doubt about the relationship between agricultural experiments and practical methods.

The first point I wish to stress is that the programme outlined above asks one or two delicate questions. As an illustration let us take the differentiation between the effect of various kinds of nitrogen. In order to answer our question it is necessary to apply equal quantities of nitrogen in inorganic and organic forms. There is no likelihood of large differences between them in crop response. It follows that a high degree of accuracy will have to be attained if we are going to distinguish differences of a few per cent between them.

I have already on more than one occasion dealt with this question of accuracy. The proof of the pudding is in the eating. From knowledge previously acquired as to the relationship between experimental design and accuracy, evidence will be given that differences of 5·2 per cent in some cases and 6·6 per cent in others can be confidently regarded as real. I do not propose to burden you with complicated mathematical conceptions, but this level of accuracy corresponds with a standard error of less than 2 per cent. I submit that such conditions provide an adequate basis for deciding the questions in hand.

The experiment consists of a large number of small 1/12th acre plots for each treatment. You may ask how far the results are relevant on a practical scale. The whole experiment covered an area of $4\frac{1}{2}$ acres. Within the limits of error aforementioned, the plots, small as they are, are truly representative of the whole $4\frac{1}{2}$ acres.

There is no need to take fright at small plot results for which an error figure demonstrating their representativeness is available. I make a special plea for consistent thinking on this subject of small samples. Estates send down to the brokers small samples of tea for valuation and report. It is never suggested that half a break should

be used for this valuation. That is because by mixing, a thoroughly representative small sample can be obtained. On the other hand I regularly received a single sample of soil occupying a few square inches of surface area from which I am requested to deduce results applicable to several acres. Such a sample is in no way representative. I hope I have made it clear that the value of a sample, be it of tea, soil or field area, is not a question of size but of representativeness. The use of small plots scattered over an area is analogous to the mixing operation in drawing a tea sample, with the added advantage that one can state exactly just how successful the operation has been. The bogey of small plots, like King Charles II, is an unconscionable time a-dying, but it is nevertheless only a bogey.

EXPERIMENTAL DETAILS.

Turning to the details of the experiment, there are three levels of nitrogen manuring and the same for potash, viz. 0, 20 and 40 pounds per acre. When combined in every possible way this gives nine different treatments relating to quality of manural application as shown by the diagram.

		0	**20**	**40**	Nitrogen
	0	0,**0**	0,**20**	0,**40**	
Potash	20	20,**0**	20,**20**	20,**40**	
	40	40,**0**	40,**20**	40,**40**	

Each of these treatments is replicated sixfold, so that questions of *balance* are decided on the basis of not one comparison but six. Questions of response to increments of nitrogen are based on no fewer that eighteen comparisons. The 36 plots that received nitrogen are divided into equal numbers receiving Blood meal, Cyanamide and Sulphate of Ammonia (i.e., 12 each), compounds which it has been customary to regard as representing an increasing degree of availability in the order stated. Potash was given in the form of muriate; the effect of phosphate cannot be judged from this experiment, as all plots received 30 pounds per acre of phosphoric acid in the form of ordinary superphosphate.

The pruning cycle is three years and the following are the dates of various operations of husbandry.

	1930	1931
Pruning	November 10-18	—
Manuring	,, 26-Dec. 3	November 23-25
Tipping	March 18-20	
	April 14-15	
	May 5	
Plucking	Regular nine-day rounds.	

Every effort has been made to secure accuracy in the routine conduct of the experiment. The correct amount of manure for each plot was weighed out into bags according to the rows to be manured in each plot. The interference of dew and rain was eliminated from plucking weights by sampling each plot in duplicate and, on the basis of the moisture determinations, reducing all yields to equivalent dry matter.

EXPERIMENTAL RESULTS.

Data are available for two complete years and the yields may be conveniently considered under the following heads:—

(1). Tipping.
(2). First year flush.
(3). Second year flush.

Tables 1 and 2 give the yields per acre for tippings and first year leaf respectively.

TABLE I

Yield of Tippings

	Nitrogen Quantities			Potash Quantities			Nitrogen Type		
	Nil	20 lb. per acre	40 lb. per acre	Nil	20 lb. per acre	40 lb. per acre	Blood meal	Cyan-amide	Sulphate of ammonia
Yield per acre lb. dry weight.	296	316	326	312	309	317	319	316	328
Significant difference lb.		23·2			23·2			28·3	
Yield per cent of mean.	94·7	101·0	104·3	99·8	98·8	101·4	99·5	98·5	102·0
Significant difference per cent.		7·41			7·41			9·08	

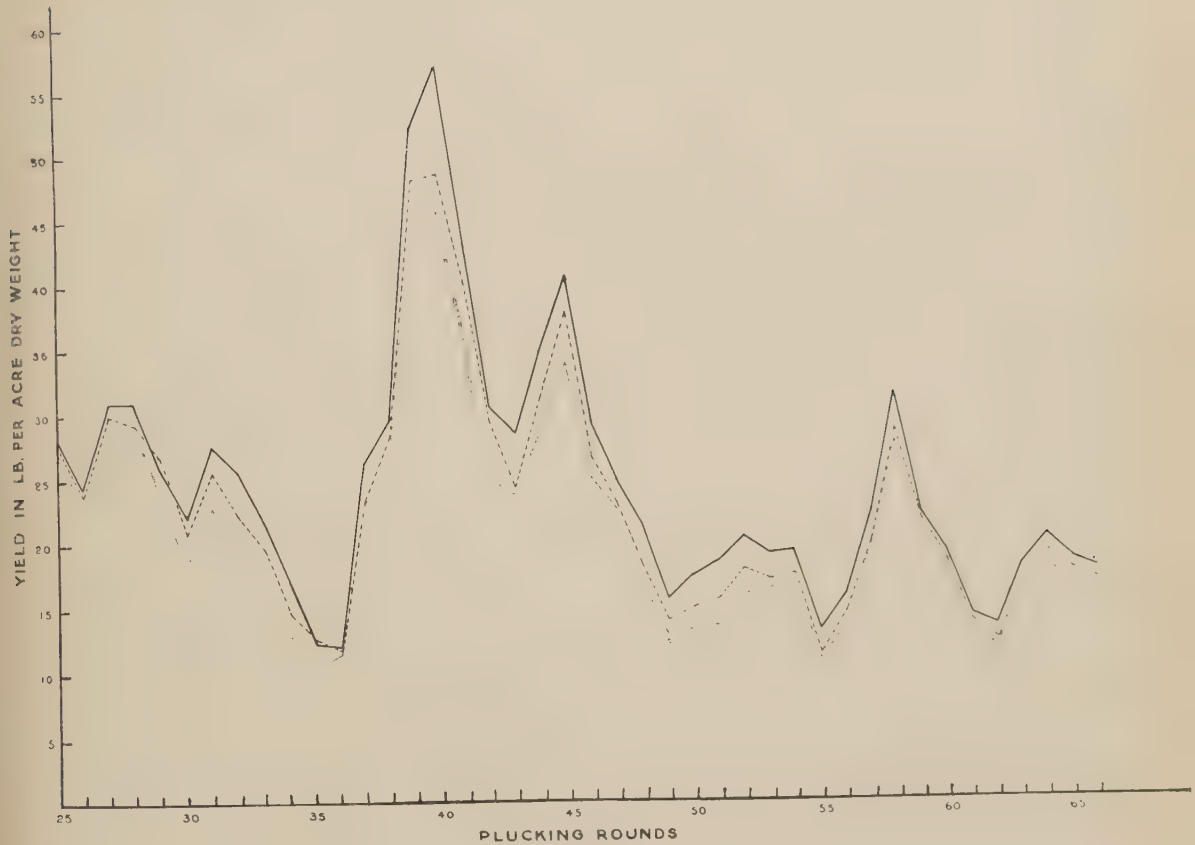


FIG. 2

YIELD PER ACRE FROM PLOTS RECEIVING VARIOUS QUANTITIES OF NITROGEN

SOLID LINE 40 LB NITROGEN PER ACRE
BROKEN LINE 20 LB NITROGEN PER ACRE
DOTTED LINE NIL

FIGURE 1 FIRST YEAR 1931
FIGURE 2 SECOND YEAR 1932

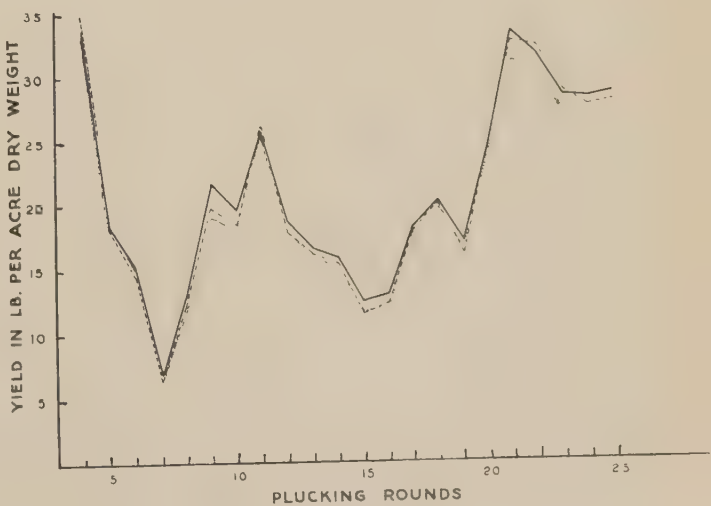


FIG. 1

Plate III.

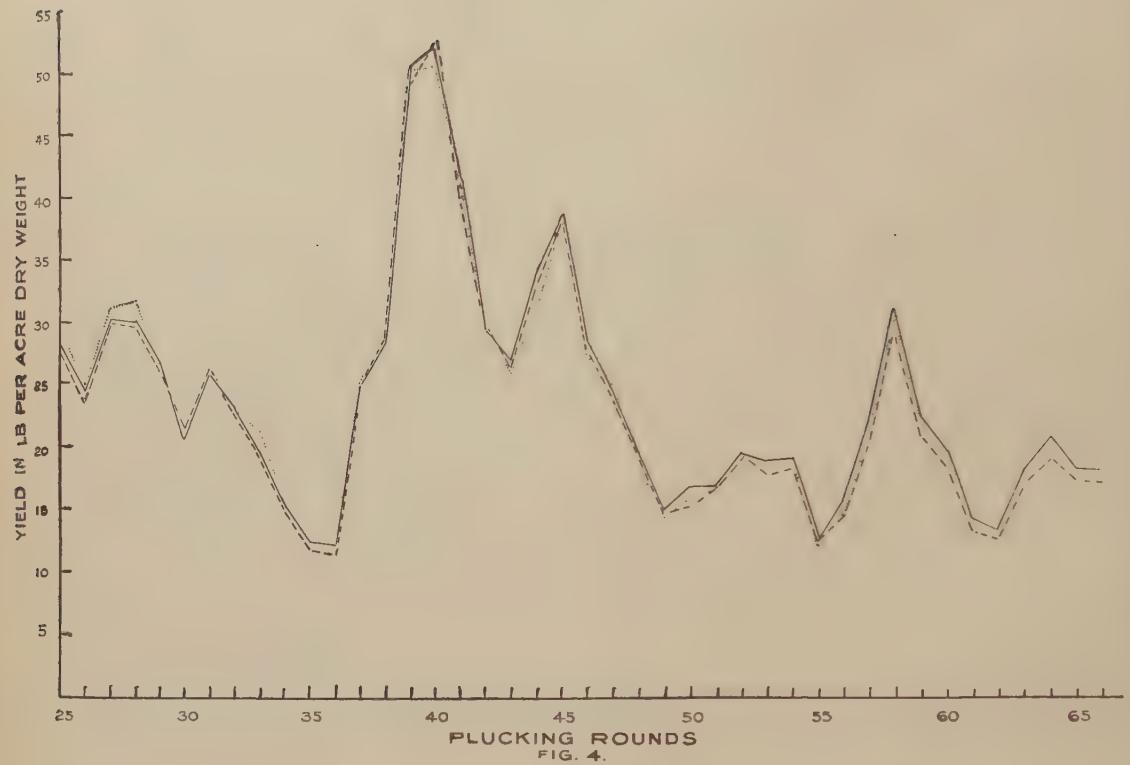


FIG. 4.

YIELD PER ACRE FROM PLOTS RECEIVING VARIOUS QUANTITIES OF POTASH

SOLID LINE 40 LB POTASH PER ACRE
BROKEN LINE 20 LB POTASH PER ACRE
DOTTED LINE NIL

FIG. 3 FIRST YEAR (1931)
FIG. 4 SECOND YEAR (1932)

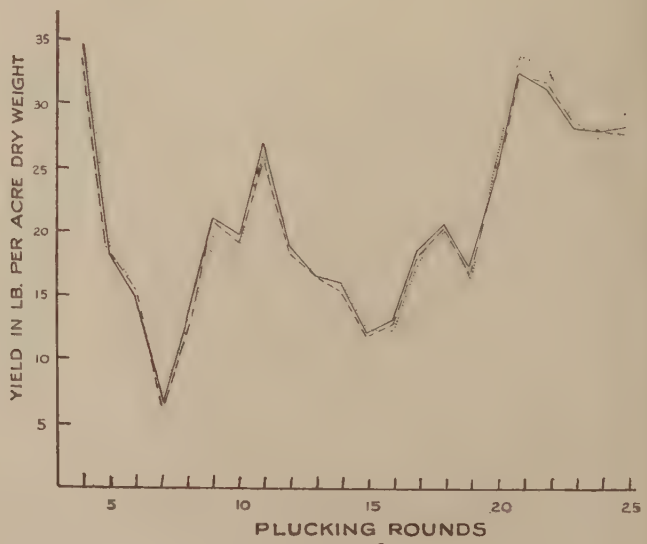


FIG. 3.

TABLE II

Yield of Flush (1st Year.)

	Nitrogen Quantities			Potash Quantities			Nitrogen Type		
	Nil	20 lb. per acre	40 lb. per acre	Nil	20 lb. per acre	40 lb. per acre	Blood meal	Cyan-amide	Sulphate of ammonia
Yield per acre lb. dry weight.	502	516	527	518	509	517	523	518	523
Significant difference lb.		28·3			28·3			34·9	
Yield per cent of mean.	97·5	100·2	102·3	100·5	99·0	100·5	100·3	99·4	100·3
Significant difference per cent.		5·5			5·5			6·7	

The yields and percentages are self-explanatory; the values for significant differences are derived from the error figures, and in this form the implications of "error" will I hope be more readily appreciated. Within the groups to which they refer, differences of yield larger than the significant difference can confidently be regarded as due to difference in treatment.

None of the treatments has had any considerable effect compared with its fellows. In fact in these two tables the effect of nitrogen on tippings is the only one that exceeds the prescribed limit. Between the no nitrogen and the 40 pounds per acre treatment there is a difference of 9·6 per cent which in relation to a significant differance of 7·4 per cent must be regarded as real.

It is of particular interest that this effect shows up for tippings and not for the flush over the whole period of a year, and consequently the figures justify further and closer examination.

A feature of the nitrogen yields which is not shared by the potash yields is that both for tippings and flush, they form an ascending series with increased manurial application. In the case of tippings just dealt with, a definitely valid yield increase has been demonstrated, but not so for the flush. The fact that this regularity does exist and that it fits in with the design of the experiment allows of a more refined test to be made with a view to determining whether

we are justified in supposing that the differences are truly connected with treatment. This test has been applied to the nitrogen yields for flush, but with negative results. Using the most refined technique available, we cannot confidently assert that flush yields have responded to nitrogen.

In passing we may emphasize again that potash, with a maximum difference of 1·5 per cent, has produced no response, and that the three types of nitrogen, all within one per cent of each other, show no difference in productive capacity. In order that you may see not only how these different plot treatments have behaved in the mass, but throughout the year the yield curves for the individual pluckings are given in Figures 1, 3 and 5. You will notice how no one treatment maintains a consistent superiority. It is this erratic behaviour due to chance causes that constitutes the errors with which have to deal.

Table 3 shows the yields of flush for the second year of the pruning cycle.

TABLE III

Yields of Flush (2nd Year.)

	Nitrogen Quantities			Potash Quantities			Nitrogen Type		
	Nil	20 lb. per acre	40 lb. per acre	Nil	20 lb. per acre	40 lb. per acre	Blood meal	Cyan-amide	Sulphate of ammonia
Yield per acre lb. dry weight.	878	942	1025	952	932	961	990	967	994
Significant difference lb.		48·9			48·9			59·9	
Yield per cent of mean.	92·6	99·4	108·0	100·4	98·3	101·3	100·7	98·3	101·0
Significant difference per cent.		5·16			5·16			6·30	

In the second year, potash and the three types of nitrogen behave in a similar manner to the first year giving only minute differences in yield not exceeding 3 and 2·7 per cent respectively, to which no reality can be attributed. The increments of nitrogen have on the other hand borne fruit throughout the year (*cf.* Figs. 2, 4 & 6)

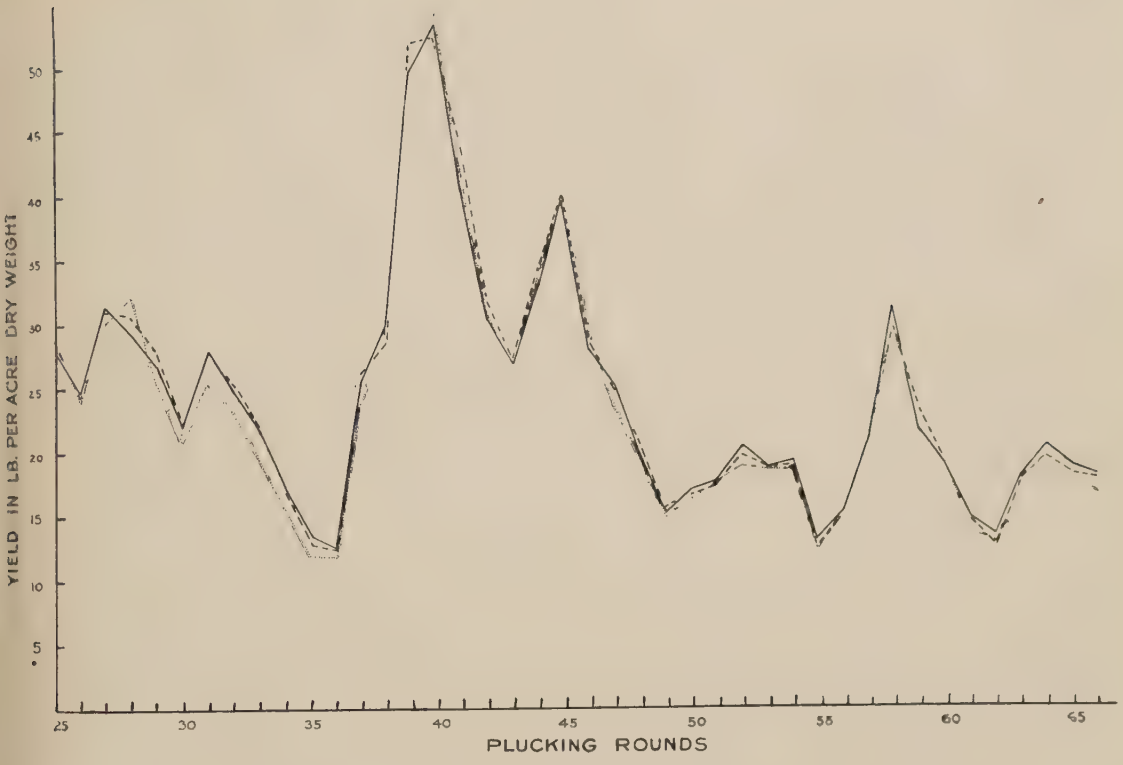


FIG. 6.

YIELDS PER ACRE FROM PLOTS RECEIVING EQUIVALENT QUANTITIES OF NITROGENOUS FERTILIZER IN DIFFERENT FORMS

SOLID LINE *BLOOD MEAL*
BROKEN LINE *SULPHATE OF AMMONIA*
DOTTED LINE *CYANAMIDE*

FIG. 5 FIRST YEAR 1931
FIG 6 SECOND YEAR 1932

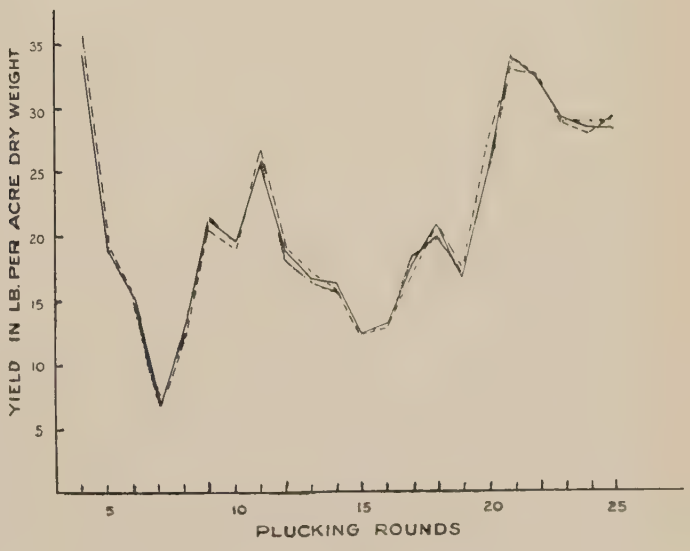


FIG. 5.

giving a gross increase of more than 15 per cent for the 40-pound application. There is no shadow of doubt that both doses have given an effective response. It is worthy of note that the increase in yield obtained from the doubling of the dose of nitrogen shows no sign of a falling off compared with the response of the first 20 pounds. Under the conditions of the experiment, 40 pounds of nitrogen have not brought yields into that region where the law of diminishing returns operates.

DISCUSSION OF RESULTS.

So far we have considered the yields only in the light of differences which can be authoritatively stated to be due to the treatments given. It remains to consider whether, real as some of them may be, they are of agricultural importance, and what inductions of wider scope may be drawn from them.

The most interesting point in the experiment is to my mind the evidence for an early response to nitrogen after pruning which is not maintained in the latter stages. It is usual, when crop forecasts are not confirmed, to blame the weather, but it is more than possible that in this case weather is the right explanation. At any rate, something limited the usefulness of the nitrogen in the latter half of the year, and 1931 was by common consent a year of heavy monsoon activity. It may be that further work will show this first year to be abnormal; or it may be that the phenomenon is a usual one. On this particular point the experiment has asked a question rather than answered it, but since it is asked in a concrete form, some progress has been made. An experiment should always ask questions as well as answer them.

The failure to establish any response to potash manuring is a point of fundamental importance. Potash is necessary to the tea plant and as a matter of fact its leaves contain a high percentage relative to many other types of vegetation. We are not justified in concluding forthwith that potash manuring can be stopped. We have yet to determine how far this nil response is due to latent supplies caused by possible over-manuring in the past. The further progress of the experiment will show how soon a falling off of available supplies comes into action. It may be objected that though flush is not affected by potash the wood is. That view is an integral part of the "watertight compartment" theory that has no very solid foundation. If potash deficiency affects any portion of the growing plant its results will ultimately be reflected in yields.

Finally, there is the behaviour of the Bloodmeal, Cyanamide and Sulphate of Ammonia. Into this aspect of the experiment the question of reserves does not enter. The organic, the intermediate and the inorganic types were given an equal trial and the result for all practical purposes was a dead heat. The data for the first year contribute little information, because the response to nitrogen being nil, it naturally is immaterial in what form it is supplied. We shall complete the pruning cycle and shall continue into another in order to make assurance doubly sure, but since these are objective results I believe they can be acted upon up to a point now.

If manuring is dropped then the yield will decline, not rapidly but a few percent at a time. These experiments give two years' grace to a scheme for economising on manures. Let potash dressings be moderate, say 20 pounds per annum, and make the best use possible of inorganic forms of nitrogen in the moderate doses covered by these results. If a slow decline sets in, the degree of accuracy to which we can work will detect it, and due warning can be and will be given.

The results I have put before you have been confined to the field aspects of manuring; that does not mean that we are unmindful of the effect of manuring on the quality of the made tea. Consideration of this aspect will form part of Dr. Evans' discourse this afternoon.

EFFECT OF MANURIAL TREATMENT OF PLOTS ON TEAS MADE*

D. I. EVANS

It was not possible during the first stage of the experiment to deal with the crop from every treatment, and it was thus decided to compare the effect of nitrogenous manuring on the quality, etc., of the teas made. The leaf harvested at each pluck from the control plots which received no nitrogen, and from plots which received a double quantity of nitrogen was sent to the factory and manfactured into tea under controlled conditions. During the first year samples were drawn from the fines by sifting out an equal quantity of tea on a hand sieve, and these samples were sent to the tasters for report. The average value for all samples during 1931 was 100 cents per pound for both the no nitrogen and the double nitrogen teas.

The teas made in 1932 from the manurial plots were graded according to the standard factory practice in St. Coombs, and a B.O.P. sample representing 40-50 per cent of the tea was sent for report. Pekoe grades were also sent occasionally but it was found that the pekoes always varied in the same way as the B.O.P., and the practice of sending Pekoe as well as B.O.P. samples was discontinued.

The usual method of reporting on teas did not show very clearly in what way the teas differed from each other, and it was very difficult to record the remarks made for reference.

This difficulty has been partly overcome by adopting a new system of reporting on the samples, and I am very grateful to all the tasters who reported on the teas for their willingness to adopt this method in spite of the extra trouble.

Briefly the method consists in comparing the experimental tea samples against a sample of factory B.O.P. which is given an arbitrary number of marks for colour, strength, pungency, quality and flavour. The liquors of the experimental samples are then given more or less marks for these characteristics according to the way they compare with the standard samples in these respects. Recently the marking system has been strengthened by the additional support of a trade valuation of the samples. In this way at least

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This paper, read during the afternoon Session by Dr. Evans is published here for convenience of reference.

three different series of marks are obtained for each set of experimental samples, and when the marks for the month are compounded and the average taken the resulting marks represent 9-12 reports.

The total average number of marks gained by the tea samples in 1932 were as follows:—

		No. Nitrogen.	Double Nitrogen.
Colour	...	332·0	309·5
Strength	...	367·0	366·5
Pungency	...	402·0	385·6
Quality	...	438·0	427·7
Flavour	...	346·0	362·2

The difference is not very great, but the no nitrogen teas have beaten the double nitrogen teas in respect of colour, pungency and quality, but remarkably enough the double nitrogen teas held the field where flavour is concerned. There does not seem to be much difference in strength as a result of manuring.

Another peculiar result is that the double nitrogen teas were preferable to the ordinary nitrogen teas in pungency and quality during the rush growth in April, and it will be interesting to see whether the effect will be reproduced in 1933.

At present these investigations are being extended so as to include a comparison of the effect of inorganic nitrogen such as Sulphate of Ammonia, and Cyanamide against Blood Meal, but the number of samples so far reported upon are too few to be dealt with.

DISCUSSION

Mr. P. A. Keiller, in opening the discussion, said that Mr. Eden had given them an interesting account ot the first manuring experiment carried out by the Institute, and although the experiment was still in its early stages, he was sure they were agreed that the results were of considerable interest, and they were much indebted to Mr. Eden for his paper.

He thought they would all have expected increased yields such as had been recorded in the second year, but the absence of response to manuring in the first year came as rather a surprise. Mr. Eden suggested that last year's abnormal weather might be the cause, and he was inclined to agree. However willing one might be to seem to evade responsibility by blaming the weather, it would be somewhat remarkable if it were proved that under normal weather conditions, a response to manuring followed during the three tipping rounds, extending over a period in this experiment of some 7 weeks and none during the rest of the 12 months. It would hardly be in accordance with estate experience, and as last year's weather was distinctly abnormal, judgment should be reserved regarding these first year results until the experiment has been longer continued.

It would be interesting if one could form an opinion whether any improvement in wood-growth had resulted from the first manurial application, but

wood-growth comparisons in a tea bush were difficult to make and hitherto one had had to be content with noting a gradual improvement, or otherwise, over a period of years.

The lack of difference in yields from organic and inorganic sources of nitrogen was not, as Mr. Eden has pointed out, very surprising. Weather conditions influenced these results in that they influenced the rate of decomposition of the fertilisers concerned, and it was conceivable, for instance, though not certain, that if conditions had been markedly in favour of the nitrification of sulphate of ammonia this fertiliser might have shown an increase in yield compared with the others.

With regard to the potash applications the chief interest lay, he thought, in determining how long they could be withheld without harm. Potash starvation brought many evils in its train, but if they were a long way from the starvation stage with regard to this or any other element none of them wished, especially at the present time, to spend money on applications which would, under these circumstances be unnecessary. It was hardly open to doubt that the nitrogen was the limiting factor in the yield of tea under ordinary Ceylon conditions and that a condition of nitrogen-starvation was easily arrived at, but regarding potash and phosphoric acid they knew very little.

There was, however, another action of potash which was he thought in most people's minds either well to the fore or in the background, but still there, and that was its action on quality. Whether it had any or not he did not know, and he would be very glad to learn. This same question of quality was also in most people's minds when considering the use of organic or inorganic sources of nitrogen. It seemed to him unlikely that either class of fertiliser had much influence on the intrinsic quality of the leaf although they might differ in the amount of leaf they produced and he suggested that by far the strongest factor in the question of quality was their old friend the weather.

A further point was whether the cyanamide offered a strict comparison with the other fertilisers because of its lime content. Cyanamide contained some 22 per cent of free lime, and tea was particularly susceptible to its action.

He looked forward with interest however as he was sure all of them did, to hearing anything which Mr. Evans might have to say on that subject that afternoon.

Mr. T. Eden, in reply, agreed with Mr. Keiller's opinion that wood-growth measurements would be very advantageous, but he regretted that he could hold out no hopes at present for the perfection of a technique of measurement that would give anything approaching reliable results. With regard to growth response in the tipping period the effect was not quite so transient as Mr. Keiller had suggested since the tipping represented growth over a period of more than five months.

He did not share Mr. Keiller's fears about the influence of the lime in cyanamide. Cyanamide was chosen because it represented an intermediate stage between sulphate of ammonia and blood meal from the point of view of the complexity of the decomposition processes. It was of course a well ascertained fact that alkalinity of tea soils was detrimental, but the quantity of lime applied was only some 50 pounds for the higher dose. When one considered that the amount of lime a temperate rainfall of 28 inches could remove annually from

the soil was several hundredweights per acre, he was not unduly perturbed. He was surprised at the small effect on soil reaction that moderate doses of lime had on Ceylon soils. He was not advocating the indiscriminate use of lime.

He emphasised the point that the data for nitrogen types brought them back to the consideration of whether the availability hypothesis in respect of organic and inorganic nitrogen would not have to receive drastic revision. He had spoken on another occasion of Dr. Joachim's data and these would take a lot of getting over. He thought that further field experimentation would give them a better clue than the more artificial and delicate work in the laboratory.

AFTERNOON SESSION.

Chairman.—Sir H. Marcus Fernando, Kt., M.D., B.Sc.,
Chairman, Low-Country Products Association of Ceylon.

Mr. R. G. Coombe said that it gave him great pleasure to express his gratification on being able to welcome such an outstanding member of the Ceylonese community as Sir Marcus Fernando. Sir Marcus had been a planter before a good many of them were born, and it was very gratifying to find that he had been able to accept their invitation to preside at the deliberations that afternoon.

CHAIRMAN'S ADDRESS.

Sir Marcus Fernando said that it gave him very great pleasure to come among them and to see them gathered in such large numbers at that Conference. He had never realised until that afternoon that there was such a keen interest displayed by the tea planting community of Ceylon in the excellent work that was being done by the Tea Research Institute. It was very gratifying to him to see that, and he was very pleased to testify from what he had heard about the work of the Institute that it was doing most excellent work to help the tea industry in the near, as well as the remote, future.

He called upon Dr. Evans to read his paper.

CERTAIN ASPECTS OF TEA MANUFACTURE

D. I. EVANS

(1) GENERAL CONDITIONS.

Officers of the Biochemical division have often been called upon to visit factories and to advise on manufacture during the last two years, and I should like to make a few remarks on this aspect of our work.

In the first place transport of the leaf into the factory appears to be one of the greatest difficulties which many Mid and Low-Country estates have to contend with, owing to the wide distribution of their divisions, and any improvement in this respect would be a great aid to them. Temperature conditions at such elevation demand that the leaf should be brought to the factory as quickly as possible to prevent heating of the leaf.

On the whole factory accommodation and equipment is better at higher elevations than at lower elevations, and it is not unusual to meet in the Low-Country with factories deficient of any fan arrangement at all, and forced to contend with conditions which fortunately we know little about Up-country. Although modern factories may not be absolutely essential for good teamaking, my firm opinion is that a good factory is a great asset, provided it is intelligently run.

There has been an advance in recent years in factory control, and although the benefit of this may not always be immediately apparent it will eventually be found of inestimable value. A few pertinent well-kept records do without doubt engender an interest in the system of manufacture and the more they are studied the more one gains from them. The collection of records is not an end in itself, it is only a guide to the proper working of the factory and very useful when it becomes necessary to alter the manufacture in some way to meet the changing market requirements.

There appears to be a certain rivalry between estates as to the prices obtained but I regret to say that there is a deplorable lack of mutual study of each others' methods throughout the Island. Again and again on visiting factories when I enquire as to how the manufacture differs from that of the neighbouring factories, I am told that it is not known, even when some of these may be attaining considerable success. It would be a great help to all if it became a habit to study each others' methods of manufacture by occasional visits

during which various problems could be discussed in the factory. Such co-operation would greatly help if well-kept records were also available.

Too often one is asked to visit a factory and to report on the manufacture as a result of the study of one day's manufacture although conditions during that day might be quite different from those usually existing. It is sometimes possible to suggest alterations as a result of such a visit, but in many instances improvement cannot be obtained by attention to one item in the manufacture since a change in one process may affect the procedure at some other stage.

I cannot, therefore, urge too strongly that every effort should be made to determine the details of the manufacture and to ascertain as clearly as possible what is the complaint. In this way it is often possible to determine what line of action to follow in investigating the trouble, and the details available indicate possible sources of trouble. I tried to overcome this difficulty by having a list of printed questions to be filled in before I visited the factories but found that in many cases these were indifferently completed by the clerk or some subordinate, so that the information was often more misleading than helpful. I am sure that you will all realise how important it is to have every information available if the full benefit of any visit is to be obtained, since it is so easy to be misled by the manufacture on one particular day.

In spite of the fact that Ceylon is supposed to maintain a standard of fine plucking, this is not the universal practice, and frequently the leaf seen on the tats has been coarse, stalky and very uneven, making for poor withering. There is room for great improvement in this respect, and it is hoped that restriction of crop when it comes will help to improve this state of affairs. If a factory must adopt coarse plucking it ought to realise this when grading their teas, and that it is not feasible to turn out such a high percentage of B.O.P. for example with a course pluck as with a fine pluck. In spite of this the tendency appears to be to gauge the success of manufacture by the percentage B.O.P. turned out. This may be excusable at a time when teas are selling well and with a fine quality tea, but not when there is no demand for anything but a tea with some stand-out characteristic. Every estate cannot turn out stand-out teas but nearly every estate can turn out a certain percentage of really fine tea provided they do not mix it with too much of the coarse leaf in their pluck.

The introduction of controlled withering systems in recent years has supplied estates with a means of controlling their manufacture to a great extent. Such systems have not always been entirely successful, and there is unfortunately a good deal of ignorance as to the manner in which these systems should be worked, thus leading to bad results. I cannot stop to enter into details, as I have dealt fairly comprehensively with this in Bulletin No. 9, but I should like to mention one or two common faults not referred to there. The first of these is that the factory which claims to use its fans the least is not necessarily the one that does the least harm with the fans and warm air. Very often a good deal of damage is done by these factories since low fan hours means somewhat drastic withering conditions for a short period. The most successful on the other hand are those that use their fans for long periods with little warm air so that the wither is continuous and not carried out spasmodically.

The other fault often overlooked is the damage done by the dryer when it becomes empty and the loft fans are running. It is very rarely that any cognisance is taken of the altered conditions when the dryer runs empty, although the temperature of the hot air to the lofts may rise from 120-220°F and continue so for an indefinite period. The air supply to the withering lofts should therefore be watched very carefully when the dryers are either being heated up, or empty if scorched leaf is to be avoided. It is now generally admitted that withering is one of the most important processes in tea manufacture, and yet it is often the least satisfactorily performed operation. As I intend to deal with this later I will now pass with the comment that a proper wither is not always obtained on estates and is the cause of a good deal of trouble.

The success or otherwise in rolling depends to a large extent on the nature of the wither, and when the tea is stated to be flaky or hard it will be found that the origin of the trouble is the wither of the leaf. I do not mean to imply that rolling can be carelessly done or cannot modify the nature of the tea according to the way pressure is applied and so on, but that most of the trouble met with in rolling has been due to improper withering of the leaf, and the non-realisation of the difference produced in the twisting capacity of a pluck by various degrees of wither. In spite of everything, convenience of working seems to be too often the criterion of when leaf is taken for rolling, and as long as factories do this trouble will be experienced in rolling.

Another fault connected with the rollers is the lack of proper co-ordination between the feeding of the rollers and the capacity of the dryers. This should be easily arranged so that the range of fermentation, i.e., the period between firing the first dhool sent to the dryers and the last is reduced as short as possible, unless the factory is very short of dryers. This range should preferably not be much more than 90 minutes and one of the most successful factories I know of aims at less than 60 minutes. The way in which this trouble arises is shown by the following example, where 3 rollers out of 4 were charged together with 600-700 pounds of withered leaf and the firing had to be carried out on one firing machine capable of turning out 80-90 pounds of made tea per hour. The result was that the dhools took 3-4 hours to be fired and the teas were poor. If two rollers were charged at a time each batch could be fired in a very much shorter period, and rolling could become continuous, although the range would be still high.

Again one meets with overcharging of the rollers especially when amalgamating the charge of two rollers into one. This results in a mass of leaf which gets little or no rolling, and also makes for high temperature conditions. If a record of the weight of dhools is kept it is easy to ascertain when the bulk of several rollers is reduced to the proportion fit for a lesser number of rollers.

More attention than ever is given to the conditons of fermentation, but unmarked dhools are still seen and these no doubt do get mixed at times. In some factories firing of the dhools is worked to a fixed programme according to the temperature of the rolling room with great success. The actual period of fermentation is very variable from estate to estate, one estate will get outstanding results with a short period of fermentation, while another estate is getting just as remarkable results with a long period, and it appears impossible to stipulate any optimum period of fermentation.

The question of tea firing in factories has occupied a good deal of time, and as this has been fairly thoroughly dealt with in recent publications, I do not propose to deal with it today. It is a great satisfaction to me that the attention focussed on this part of the manufacture has awakened interest in the efficiency of dryers by the engineers, that a greater understanding of this process is developing and that improvements in the dryers themselves are almost certain to be produced. A good deal of the trouble met with on tea estates has been connected with the drying of the tea, and further there is

no doubt but that greater economy without loss of efficiency can be obtained at this stage.

Finally it seems to me that greater attention could be given to maintenance and cleanliness in many factories, especially in the withering lofts, drying room and grading room floors to prevent sand getting into the teas. The roll breakers are also too often in a bad condition as regards the tightness of the mesh, and I regret to say of low efficiency owing to closing of the mesh by stale leaf.

(II) THE IMPORTANCE OF MOISTURE IN TEA

In my address to you at the last Conference I pointed out that the range of variation in the moisture associated with the leaf coming in to the factory was very high, and that this variation was an important factor in tea manufacture. Subsequent investigations here at St. Coombs and in other factories support this contention and show that the removal of this moisture is of the greatest importance for successful tea manufacture.

The determination of the dry weight of the leaf received in the factory during the day shows a high variation from weighing to weighing, which is not surprising in view of the variable weather conditions during the day. The manner in which this variation in moisture content affects the manufacture is seen when the weight of water evaporated per unit of dry tea produced is considered. Thus on one day the following differences were obtained in the weight of water evaporated during manufacture to produce a pound of dry tea.

		Lb.
Morning leaf	...	3·70
Noon leaf	...	3·12
Evening leaf	...	4·00

The variation in moisture content is almost entirely due to more or less surface moisture as a result of rain, no rain or dew at the time of plucking, and since it is so variable during the day it means that conditions of manufacture may be very different for the different weighings.

The actual moisture of the leaf has been determined each day for a whole year and without entering into details it may be said that the range of variation is very high. The lowest figure recorded was 67·5 per cent while the highest figure was 84·7 per cent moisture, i.e., a little more than 2 pounds of water had to be evaporated to produce a pound of dry matter in one instance and 5·4 pounds in the other.

This means that considerably more work must be done on the last to produce a pound of tea, and should indicate very clearly one difference between tea manufacture with wet leaf in wet weather as compared with dry leaf in dry weather.

Although the highest figures are obtained during the wet months, it is not unusual to meet with high figures in the middle of the drier months. What I want to impress on you is the direct way in which this variation in moisture affects the manufacture.

Suppose we take the leaf which contained 57·5 per cent moisture and withered this down to 55 per cent. The withered leaf would then contain 41 per cent moisture. The leaf which contained 84·7 per cent moisture would contain between 71 and 72 per cent moisture. I do not think much thought is necessary to show that this will have a very marked effect on the later processes of manufacture.

It may be counted that such poorly withered leaf is not met with in practice, but it was not many weeks ago that I visited an estate where the out-turn of made tea on withered leaf varied between 24·8 and 48·5 per cent equivalent to 76-77 and 53-55 per cent moisture in the withered leaf. This is not the only instance but it is illustrative of the extreme conditions met with.

What sort of variation is found in factories where controlled withering is feasible and the leaf is withered until it is considered ready by sense of touch, smell and appearance? This has been found by determining the actual moisture content of the withered leaf each day for a year. In terms of the quantity of moisture evaporated in drying per pound of dry tea turned out the range for the year was 0·71-1·53, i.e., the variation in moisture content of the withered leaf was between 60 and 42 per cent. The variation is therefore very high and I have yet to be convinced that this record obtained by careful measurement is not representative of conditions throughout the Island.

Again the variation in the moisture content of the withered leaf of different roller charges is quite high, and although the average out-turn of made tea for the day may appear satisfactory the conditions may have been very bad. Two sets with an out-turn of 40 and 60 will give an average out-turn of 50, but a proper wither was not obtained in either of them. This is a state of affairs often met with when morning, noon and evening leaf are considered. The morning leaf gets the hardest wither, and the evening leaf the lightest, the average appearing more or less satisfactory.

It is thus clear that in general practice leaf containing very variable quantities of moisture is taken for manufacture, and that this affects the subsequent processes of manufacture as follows:—

(1). *Rolling.*—If the leaf is not properly withered it will not twist easily, and it is not possible to standardise the method of rolling. Separation of dhools will be affected, and flaky tea is liable to be produced.

(2). *Fermentation.*—This will be irregular because the sap concentration will vary according to the moisture present in the leaf, since the speed of chemical reactions depends to a certain extent on the concentration of the reactants. There can therefore be no uniformity of the fermentation until evenly withered leaf is obtained. Dr. Shaw of the Scientific Department in South India goes even further and stipulates that the leaf should be withered so as to give the same concentration of tannin in the sap each time. This is based on sound reasoning but if as a first approximation we can work to a wither giving constant moisture it will be a tremendous step forward.

(3). *Firing.*—In my opinion successful and economical firing can only be approximated to when the fermented leaf taken to the dryers contains a uniform quantity of moisture. No machine can deal satisfactorily with leaf containing 60 per cent moisture at one time and only 40 per cent at another time, and be economical. Much of the trouble experienced in drying would be eliminated if a factory can ensure a supply of uniform material to the dryer.

The first essential is therefore to obtain a uniformly withered leaf at all times if good manufacture is to follow, but the difficulty is to determine when the leaf is properly withered. It can be minimised if proper care is taken that the leaf is taken to the rollers when ready and not when the rollers are ready, and the fans are properly worked. Further, apparatus have been recently introduced to help in gauging the wither. They are not yet perfect by any means but once the idea is put into operation improvements will follow, and withering of the leaf will become precise instead of the haphazard process it is at present.

The first gauge to be marketed is that of Messrs. Avery who introduced the flat tat of 15 square feet attached to a sensitive

balance for withering a pound of green leaf in the lofts. Unfortunately few factories can accommodate the single tat arrangement, and at my suggestion they introduced a tier of smaller trays of such a size that they can be introduced and hung between the banks of tats in a loft. The present one is experimental but I have found it quite satisfactory, provided the spread of the green leaf is uniform and at the same rate as on the experimental tats. If wet leaf comes in it is advisable to take the leaf for spreading on the Avery tat from the factory tats after the surface moisture has been removed and then treat this as dry leaf. With a little practice it will be found that satisfactory results can be obtained.

The other gauge is one patented by the Colombo Commercial Co., Ltd., and which works by measuring the volume of sap in the withered leaf. The leaf is crushed, and a definite weight of it placed in the apparatus. It is then submitted to a pressure of 5,000 pounds per square inch for 5 minutes and the volume of sap squeezed out measured in a graduated tube. The amount of sap squeezed out is proportional to the moisture in the leaf, and properly withered leaf should give the same reading each day. Both sets can be seen after the meeting.

The quantity of moisture left in the dry tea is also of importance from the point of view of the storage properties of the tea and should not be lost sight of. Most estates are aware of this difficulty and have taken steps in recent years to control the moisture content of their teas, so that they do not contain too much moisture when packed. It does not necessarily follow that this is an absolute safeguard but it will reduce the risks to a minimum. It is, however, just as necessary that the teas stored in the factory have also been properly fired, otherwise deterioration will take place in the bins in spite of the fact that they may be of excellent construction. Aeration is not necessary for the growth of many moulds, so that enclosing a badly fired tea in airtight bins does not prevent the growth of moulds if the moisture conditions in the tea are suitable for them. Final firing of a tea which has gone off to a certain extent in the bins will check any further deterioration if properly carried out, but it does not cure the evil already done.

Unfortunately final firing is not properly carried out at all times according to many of the samples received by me. It is quite common to find the same quantity of moisture in the final fired tea as in the tea not final fired, and in almost every instance the tea has

been pushed through the machine quickly at a low temperature. With such low temperature as 140-150°F it will be necessary to leave the tea in the machine for about 10-15 minutes if the excess moisture in the tea is to be driven off.

I regret I cannot give definite directions for final firing, but it it is very easy to check the moisture in the tea final fired and determine the most suitable conditions. If high temperatures are used for final firing then a quicker passage is necessary.

DISCUSSION

Mr. T. H. Williams said that he had listened to Dr. Evans' address with great interest, and he felt sure he was voicing the sentiments of the meeting when he said how sorry they were to lose Dr. Evans.

The first point he wished to raise was one he had already mentioned to Dr. Norris, namely that there should be more opportunities for instruction at the Institute. He referred principally to the Assistant Superintendent who on taking charge of an estate had practically no knowledge of teamaking and who consequently acquired his knowledge at the expense of the owners. Such a thing would not be allowed in any other profession. Could they imagine, for instance, a brewer getting a billet if he know nothing about making beer?

There were several points on which information was required. What happened to their tea between its leaving Ceylon and its arrival in London? Something undoubtedly happened; in some cases the tea improved and in others it deteriorated. They had practically no knowledge of the condition of any particular tea when it reached the consumer. Enquiries in London and in Colombo regarding the keeping qualities of tea produced the replies that no information was available. That, however, could not be correct as he had had conversations with gentlemen in the tea trade who had travelled through America and Canada, and they had told him that certain marks had poor keeping qualities and consequently were black listed, but he had never been told of any mark that was definitely on the black list.

He also thought that they were becoming too scientific. After all what was required was that they should make tea which would fetch good prices. He suggested that they should have informal meetings at the Institute, and that the Staff and practical planters should give lectures, the meetings to be as informal as possible. With such informal discussions he was perfectly certain that they could get to the bottom of a great many of the difficulties which had not been overcome at the present.

Dr. Norris replied to the point raised regarding instruction. He quite realised that that work should fall within the sphere of the Institute's activities. The difficulty however was the provision of accommodation for those attending the courses. He was most anxious to have short instructional courses at St. Coombs, not only in connection with manufacture but to deal with other subjects as well. The sole difficulty was one of accommodation. If a solution to the difficulty could be found, arrangements would be made for instruction of the desired type to be given.

As regards informal discussions on manufacture, he agreed that they would serve a most useful purpose. At the first opportunity he would endeavour to make arrangements for such informal discussions, but the interregnum between Dr. Evans' departure and his (Dr. Norris') return from leave would possibly cause a little delay. During the last six months members of the Staff had addressed a number of District Planters' Associations and on such occasions informal discussions had normally followed.

Dr. Evans regretted that information regarding what happened to teas in transit and storage was almost negligible. Packing teas with the correct amount of moisture would minimise any danger of the teas going off, but it was possible that some teas went off as a result of some wrong condition during manufacture.

Dr. Norris said that with regard to the question of teas going "off" in transit, he would stress the fact that Superintendents should be able to obtain further assistance through their tasters and brokers as to the direction in which deterioration had taken place. At present very little information of this nature was normally available. If such information could be obtained, it might give a clue for determining the cause.

Mr. S. Howard asked for a definition of quality in tea.

Dr. Evans stated that he had no definition to give. He was entirely in the hands of the tasters who were the final arbiters in the matter.

In reply to a question regarding the necessity of fans in the withering lofts, **Dr. Evans** stated that the fans afforded a means of obtaining a proper wither of the leaf and thus ensured a proper condition for rolling at all times. He had at no time claimed that the use of fans would give quality teas.

Dr. Norris said that many people had prejudices against artificial withering and the use of fans. He suggested that in many cases it was not the *use* of fans that spoilt the teas but the *misuse* of them. Artificial withering required careful study as the methods were not particularly simple, and if improperly used, bad results undoubtedly followed.

Mr. Marsh Smith asked for information regarding the effect of the period of withering on the colour of the tea.

Dr. Evans said that the length of the period of withering was undoubtedly intimately connected with the amount of colour obtained in the liquors of made teas. He had carried out experiments during the last year to determine the effect of the period of wither on the quality and characteristics of the tea. Various withers from 4½ to 45 hours had been compared but the results of those experiments had not been referred to that afternoon because they were obviously incomplete. A long slow wither had, however, quite definitely given colour, but at the same time in all his experiments that gain in colour had been associated with a definite loss of pungency, quality and flavour. He would not like to say that it was impracticable or uneconomical to give up the idea of slow withering, but at certain times of the year when there was little quality in their teas and the market demanded colour and strength, under those conditions it might be advisable to resort to longer withering in order to produce those characteristics in the tea.

Experiments had also been laid out to test not only the period of wither but also the degree of wither. At the same time he had also tried out the effect

of fermentation on leaf subjected to various periods of wither, but so far he had not obtained any very conclusive evidence one way or other as to how the length of withering affected the fermentation of the leaf.

Mr. J. P. Blackmore said that he had heard of estates firing their leaf before it was hardly fermented at all and of others which fermented for four hours. He asked whether any experiments had been carried out to determine what length of fermentation gave the best results.

Dr. Evans replied that such experiments had been carried out and were reported in the Annual Report for 1931. Since then further experiments had been carried out at St. Coombs to ascertain whether more coloury teas could be produced by long fermentation. The results showed that there was a fairly wide range of time of fermentation within which favourable reports could be obtained from different brokers. He had taken samples of tea fermented from ½ to 24 hours and had sent them to a number of brokers. He received a series of favourable reports covering a range of 2 and 4½ hours. The only conclusion he could arrive at was that teas fermented to different degrees met certain market requirements, dependent on the broker. What particular demand their teas should meet must be determined by each estate.

Mr. Scott asked whether heavy pressure in the early roll spoiled quality.

Dr. Evans replied that pressure had no effect on the quality of teas except indirectly. If hard pressure was applied to the early rolls, as much as 20-25 per cent of the leaf would be obtained in the first dhool, and thus there was a tendency to dilute the fine leaf with coarser leaf. If hard pressure is carried too far there was also discolouration of the tip and it became impossible to turn out F. B. O. P. which had been doing well during the last year.

Mr. Sydney Smith said that the suggestions made by Mr. Williams and supported by Dr. Norris were of considerable importance. He referred to the necessity for instructional work at the Institute and for informal discussions. Dr. Norris had told them that the difficulty was the provision of accommodation for those attending the course. He considered the courses and discussion to be of paramount importance and that some form of resthouse should be provided. He did not see why the provision of such accommodation should be a very expensive matter. Something on the lines of the huts at Diyatalawa camp, with cubicles, would not cost a lot of money. It was essential that those attending the course should be able to stay at St. Coombs for a night or two, they could take part in discussions or receive instruction and see what was happening. He considered that only a small expenditure was necessary for the purpose of providing accommodation but he felt sure that it would bring a good return.

Mr. R. C. Coombe said that on behalf of the Board of the Institute he welcomed the suggestion made by Mr. Sydney-Smith regarding the necessity of accommodation for visitors on St. Coombs. Those who had followed the proceedings of the Board would have noticed that on more than one occasion the question of a resthouse had appeared in their estimates but the Board after careful consideration had felt that other accommodation requirements, namely those of the Staff, were of more paramount importance, and the provision of a resthouse had reluctantly to be postponed. On behalf of the Board he could give them the assurance that the matter to which Mr. Sydney Smith had referred would receive very careful consideration. The provision of a resthouse would not be possible during the present year, but they might rest assured that it would be at the top of the list of new works for consideration of inclusion in the budget for the coming year.

TEA CIDER

C. H. GADD.

At various times in the local Press there have been references to a beverage termed Tea Cider, and it is my purpose this afternoon to explain briefly what that beverage is, and why the T. R. I. has interested itself in the subject.

During times of depression, producers naturally view their excessive stocks with concern, and have recourse to various methods to reduce them. Excess stocks may be destroyed, as is said to have occurred with coffee, or committees may be set up to consider new uses for the product, as with rubber. The methods, however, which make most appeal are those which lead to a greater consumption of the product by increasing both the number of consumers and the amount used per head. Hence the prevalence of such slogans as "Eat more bananas" or "Drink more tea".

No one here, I am sure, will deny the excellence of tea as a beverage, but we should all be surprised if it were offered at the next St. Andrew's dinner. Lest there be any misapprehension, I do not suggest that there is any likelihood of our friends from north of the Tweed forsaking their national beverage, in order to help to reduce our tea stocks by taking to Tea Cider. But I do suggest that by offering other tea beverages, in addition to that in the form so well known, there is an increased possibility of giving greater effect to the "Drink more tea" slogan, even in those countries where tea is much used.

What then is Tea Cider? It may be described as a pleasant, slightly acid, effervescent and refreshing drink made from a sweetened infusion of tea. It has a bouquet and flavour of its own, and bears no resemblance to the commonly known tea beverage. It somewhat resembles the cider made from apples, and so has been called Tea Cider.

In all probability, Tea Cider is a drink which has not been evolved in a Chemist's nor a Biologist's laboratory. How it originated we do not know. Its origin appears to be lost in history or mystery, but one can imagine it having been discovered accidentally, approved, and preserved, though not quite on parallel lines with Lamb's story of the origin of Roast Pork. It is, however, not a new drink designed especially for the depression. According to

Dinslage and Ludoff it was introduced into Germany about 1911, presumably from Mitau, Courland, in Russia. Its introduction into Mitau is within living memory, and there it is said to have been introduced by sailors. But whence the sailors got it, we do not know. Judging from the names by which the ferment is popularly known in Germany—for instance Japanese, Manchurian and Indian tea fungus—it probably derives from the Orient. In Java it is said to have become a popular drink among the inhabitants; this appears to be due largely to the activities of a certain gentleman's chauffeur who has taken a very active interest in the distribution of the ferment. He is reputed to receive as many as 200 applications a day for the ferment for brewing the cider.

The ferment appears to be homogeneous mass, but actually it is a mixture of organisms of which, in my opinion, only two are of importance. One is a yeast (*Saccharomycodes Ludwigii*) and the other a bacillus (*Bacterium xylinum*). The actual identity of the yeast does not matter materially, as good Tea Cider can be brewed with cultures containing other yeasts than this particular one, (*Saccharomycodes Ludwigii*). *Bacterium xylinum* appears to be more important as it is the action of this particular bacterium, working on the products of fermentation brought about by the yeast, which gives rise to the characteristic flavour and odour of Tea Cider.

As the ferment is a mass of living organisms it obviously cannot be made by mixing together ingredients from a Chemist's store. It can only be obtained from existing cultures. The Tea Research Institute is now in a position to supply the culture on application.

The process of manufacture of Tea Cider is simple. All that is required is a tea infusion prepared in the usual way, using $1\frac{1}{2}$ ounces to 2 ounces of tea to a gallon of boiling water. The leaves must be strained off and 10 per cent sugar added, i.e., 1 lb. to 1 gallon of infusion. This is placed in a wide mouthed vessel and allowed to cool.

When cool, the ferment is added and the vessel covered to keep it dustproof but not airtight. During this process the sugar is attacked by the yeast and converted into alcohol and a gas (CO_2). The latter escapes, but the alcohol is worked upon by the bacterium to produce acetic acid and other compounds. It is the combination of these actions which gives the characters of the cider.

The infusion is at first sweet but this sweetness disappears as the sugar is broken down. At the same time an acid flavour begins to develop owing to the activities of the bacterium, so there is a transition from sweetness to sourness. If a slightly sweet drink is preferred the brewing is stopped earlier, whereas it is continued longer if a dry, or slightly acid, flavour is required. For most people, the right stage is just as the sweetness disappears but before a pronounced acid flavour is evident.

It is quite impossible to lay down any hard and fast rule regarding the length of time the brewing should take, as it depends largely upon temperature and the activity of the ferment. As a rule the higher the temperature, within limits, the more active is the ferment. The optimum period for brewing has to be determined for each set of circumstances. This however is an easy matter; it is purely a question of tasting the brew at intervals after the first day. At St. Coombs the process takes from 2-3 days, at higher elevations it may take longer, while at lower elevations a shorter time will suffice.

When the infusion has attained the right flavour, it is filtered through a double thickness of linen, such as a table napkin, and placed in bottles. The bottles should be completely filled and securely stoppered. If corks are used they must be tied down.

The activity of the bacterium is stopped by the bottling which excludes the air, but the yeast continues to work. As the bottles are securely stoppered the gas produced by the yeast's activities, is unable to escape, and so an effervescent drink is produced. A few days in the bottles is usually sufficient; the cider, however, will keep well for a month or two. It is advisable to keep the cider in a cool place, otherwise there is a risk of the bottle bursting, owing to the pressure of gas inside. If on opening, the cider is found to be flat, the fault will usually be found in a leaky stopper.

It is also possible to prepare an excellent vinegar from a sweetened tea infusion. One proceeds exactly as though tea cider is being prepared, but instead of bottling the brew after 2 or 3 days, it is allowed to remain in the open vessel for about a month. Then the vinegar should be strained, boiled and bottled. Acetic acid, or vinegar, prepared in this way may possibly be useful for coagulating latex in the preparation of rubber. If our friends of the Rubber Research Scheme have not already seen a note to this effect in the local Press, we will make them a present of the information.

The ferment itself which forms a film on the surface of the brew is apparently not without its uses. In Germany, a company (The Auer Company) grows the film solely for use in the manufacture of artificial leather goods, such as gloves, bookbindings, and fancy goods. If this industry proves the success hoped for, we may see a severe depression amongst the bagworms who, (*vide* the editorial of the last *Tea Quarterly*,) are producing material for that class of goods.

To return now to our main topic, you will realise from the little I have said of the chemical processes which take place during preparation, that Tea Cider contains alcohol, but the quantity is, however, very small. It is rarely that the amount exceeds one per cent. If a potent drink is required, I am afraid that the spirit has to be added to it. I am informed that rum makes a good 'dilutant'. The presence of alcohol, even in so small a quantity, brings the sale of the Tea Cider under the Excise Laws. This is unfortunate, because it prevents our aerated water manufacturers from putting on the market a wholesome, refreshing drink.

It should, however, be borne in mind that Tea Cider is easily and cheaply prepared in the home. In Java, where it has achieved a considerable degree of popularity, Tea Cider is mainly home brewed though it can also be readily purchased too. Personally I am of the opinion that home brewing should be encouraged.

I am not advocating the illicit preparation of intoxicants; it would require some stretching of the imagination to class a well-brewed tea cider as an intoxicant. Where this beverage is best known, it has been preserved for its reputed medicinal qualities and not for its very doubtful ability to produce inebriation. Though Tea Cider may have medicinal values which possibly can be substantiated, it is as a wholesome, refreshing beverage that I advocate it.

If you are interested in the possibilities of this little-known method of preparing a tea beverage, I have a number of samples of the ferment for distribution this afternoon. If there are not enough to go round, samples will be posted as soon as they can be prepared to those leaving their name and address. Having obtained a sample and a copy of instructions for its use, don't throw them away. Make tea cider and distribute your culture to others. It is quite easy to start new cultures from fresh cider; the more cultures there

are in use, the more tea will be used in the preparation of this tea cider. It may interest you to hear that I have received my first request from America for a culture this week. People want a new drink; why should not it be Tea Cider?

DISCUSSION

Mr. Stanley Howard asked how Dr. Gadd obtained such a clear cider. He had been making tea cider for some time but always obtained a thick sediment in it. He filtered through thick linen.

Dr. Gadd replied that in the laboratory he used filter paper or blotting paper for filtering the cider before bottling. There was always a certain amount of sediment formed after bottling but that could not be avoided as it was due to the growth of yeasts which produced the gas to aerate the cider.

Mr. Bruce Foote asked whether the colour of tea vinegar which had been recommended for the coagulation of rubber latex would be deleterious for the purpose.

Dr. Gadd replied that he had not carried out any experiments on the coagulation of rubber latex with the tea vinegar. He had shown that an excellent vinegar could be made very cheaply from tea, but he would prefer to leave to the Rubber Research Institute the investigations of its application in the rubber industry.

The Chairman said that Dr. Gadd had mentioned Java in his account of tea cider. In Java they used tea cider because the people, like the Malays, had a great prejudice against drinking anything of an intoxicating nature, like palm toddy. In Ceylon they had not that prejudice and they had toddy, which was a common drink fermented somewhat like tea cider. This cost about 20 cents a gallon, and contained about 6 per cent alcohol. He did not think, therefore, that there would be a great demand in Ceylon for tea cider with its 1 per cent alcohol. He considered that it would be useful to the tea industry if tea cider became popular amongst the masses.

Dr. Gadd said that tea cider would compare quite favourably with toddy as regards cost, as a gallon could be made from 1½ ounces of tea and 1 pound of sugar which would not cost more than 20 cents, the price mentioned for toddy. But he certainly had to give way to toddy as regards its alcohol content.

The Chairman said that it was his pleasant duty to propose a hearty vote of thanks to the two gentlemen who had read such interesting papers to them that afternoon. In the case of Dr. Evans, it had been a very great pleasure to him to listen to all the interesting points he had made in connection with the manufacture of tea. They were very sorry to lose Dr. Evans and they would not only accord him a hearty vote of thanks but wish him a successful career elsewhere. In the case of Dr. Gadd, he had made his observations with very piquant phrases. He hoped that a market would be found for tea cider, if not in Ceylon, in America from where Dr. Gadd had already received his first request.

Mr. R. C. Coombe said that before concluding their deliberations it fell to him on behalf of the Board of the Institute to express their appreciation of the really good attendance. At their Conference two years ago, they had a record attendance, but he thought that afternoon's just beat it. He would say that it gave them encouragement to carry on, and he was quite sure it was a great tribute to Dr. Norris and his Staff for the work they had done since they met two years ago. Several of them, including their Director, had expressed their regret at losing the services of Dr. Evans. Speaking on behalf of the Board, he desired to associate himself with those remarks. Since Dr. Evans joined them, he had whole-heartedly co-operated in every way possible in the endeavour to work out many of the very difficult problems they had to face in connection with tea manufacture in the present day. He (the speaker) had been a tea planter for over 40 years, but he did not hesitate to say that he still knew very little about tea manufacture.

He was sure he was expressing the opinion of all present when he said that they wished their Director a really good holiday at Home. He was leaving them next week on well-earned leave and during that time, he had told them, he was going to endeavour to obtain another officer to fill Dr. Evans' place. He felt sure that Dr. Norris would not let them down in that respect.

In conclusion, he again thanked them for their attendance and he hoped they would go on showing confidence in the T. R. I. which, he asked them to believe, deserved their support.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Grand Oriental Hotel, Colombo, on Friday, the 15th December, 1932, at 9-30 a.m.

Present.—Mr. R. G. Coombe (Chairman), the Acting Financial Secretary (Mr. C. W. Bickmore), Col. T. G. Jayewardene, Major J. W. Oldfield, Messrs. A. G. Baynham, G. K. Stewart, M.S.C., D. H. Kotalawala, M.S.C., R. D. Morrison, I. L. Cameron, John Horsfall, Jas. Forbes (Jnr.), A. W. L. Turner (Secretary), and as visitors, Mr. J. W. Ferguson, Dr. Roland V. Norris (Director, T.R.I.), and Dr. C. H. Gadd.

1. Notice calling the Meeting was read.

A letter regretting inability to be present at the Meeting was received from the Director of Agriculture.

The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 28th July, 1932, were confirmed.

2. CHAIRMANSHIP.

Mr. R. G. Coombe announced that he had returned from leave and resumed the Chairmanship as from the 26th November. He proposed that a vote of thanks be recorded to Mr. G. K. Stewart for having acted as Chairman during his absence.

3. MEMBERS OF THE BOARD, T. R. I.

Announced that Mr. Jas. Forbes (Jnr.) returned from leave and resumed his seat on the Board as from the 16th November.

Votes of thanks to Messrs. C. C. du Pré Moore and C. Huntley-Wilkinson for having acted for Mr. Jas. Forbes (Jnr.) and Mr. R. G. Coombe respectively were recorded.

Welcomed Col. T. G. Jayewardene who had been nominated by the Low-Country Products Association *vice* Mr. C. H. Z. Fernando who resigned as from the 22nd August.

4. FINANCE.

(a) The Statement of Accounts as at 30th November were tabled.

On the proposal of Major Oldfield, seconded by Col. Jayewardene, the accounts as at 30th November were adopted.

(b) *Estimates of Income and Expenditure for 1933.*—The Chairman announced that the Finance Sub-Committee had held a Meeting on the 26th November, a copy of the Minutes of which had been sent to each member of the Board under cover of Circular No. A.26/32 of the 5th December. The Estate Estimates had been further considered by the Experimental Sub-Committee at St. Coombs on the 13th December and both the Research and the Estate Estimates had again been considered by the Finance Sub-Committee on the previous day. Copies of the final Estimates were tabled.

Research Estimates.—It was decided that the Research Estimates for 1933 be adopted.

Estate Estimates.—There was a discussion on the question of opening more land and it was finally decided, with Mr. Jas. Forbes (Jnr.) dissenting, that no further land should be opened during 1933.

In reply to a question by Col. Jayewardene *re* Manuring, the Director stated that it had been decided to use inorganics rather than organics with a view to lessening the cost of this item. He expressed the opinion that it was the duty of the Institute to carry out large scale experiments of this kind for the benefit of the industry.

It was finally decided that the Estate Estimates as tabled should be adopted.

It was also decided that a small General Reserve should be created as and when possible, it being considered essential that the Institute should have funds available for the purchase of new machinery, etc. This General Reserve is to be supported by cash on Fixed Deposit at short call.

5. TRAVELLING ALLOWANCES.

Announced that as a result of circulation of papers it had been decided that travelling allowances should be paid to members of the Board at a flat rate of 25 cents per mile to cover *all* expenses. This decision was confirmed.

6. SENIOR SCIENTIFIC STAFF.

(a) *Director, T. R. I.*—Announced that the Director was due to proceed on leave on the 16th December, 1932, but in view of the coming Conference he was agreeable to postpone his departure until the 8th February for $8\frac{1}{2}$ months.

The Director's agreement was renewed for a further period of 4 years as from the 12th August, 1933.

(b) *Acting Director.*—It was decided that Dr. C. H. Gadd should act as Director of the Institute during Dr. Norris' absence.

7. JUNIOR STAFF.

Mr. I. R. Nicol, Field Assistant in the Department of Physiology.—Announced that this Assistant's services were terminated on the 30th September.

Mr. F. H. Kehl.—Announced that this Assistant had succeeded Mr. Nicol as from the 1st October, 1932.

Provident Fund of the Junior Staff.—Announced that Mr. Jas. Forbes (Jnr.) having returned to the Island had relieved Mr. A. G. Baynham who had acted for him as a Trustee on the above Fund.

Mr. Baynham was thanked for the services he had rendered.

8. BUNGALOWS.

Announced that the Senior Staff Bungalows Nos. 3 and 4 were taken over and occupied as from the 1st August.

9. ST. COOMBS ESTATE.

(a) *Visiting Agent's Report.*—Announced that the Visiting Agent's Report, dated the 5th September, 1932, had been sent to each member of the Board, under cover of Circular No. A.18/32 of the 13th September, and in view of his recommendations, the Board had decided that no pruning mixture should be applied to Field No. 8 in 1932.

Tea Manufacture.—The Acting Chairman's instructions that the factory should be largely used for experimental purposes were confirmed.

In this connexion the Director stated that a small Advisory Committee consisting of the Biochemist, the Superintendent of the Estate and himself had arranged to meet once a fortnight to discuss manufacturing problems. He undertook that a full report would be issued shortly to each member of the Board.

In connection with Manufacture, Mr. Stewart suggested that further Conferences between buyers, brokers and officers of the Institute should be held.

The Chairman undertook to see that this would be arranged.

10. SMALL-HOLDERS.

Announced that 101 applications had been received for the post of Small-holdings Officer and that Mr. R. L. Illankoon had been appointed as from the 1st October, 1932.

Attention was drawn to a Memorandum drawn up by Dr. Gadd indicating the lines on which this officer would work, a copy of this Memorandum had been sent to each Member of the Board.

Mr. Kotalawala thanked the Director and the Chairman for the speed with which this appointment had been made and enquired what further action would be taken in the near future.

The Director replied that Mr. Illankoon was now going over his district and getting into touch with the Small-holders and with village officials and organisations. He would shortly put up proposals in regard to the demonstration plots. On receipt of Mr. Illankoon's report, he would examine these areas personally.

Col. Jayewardene suggested and it was agreed that a half-yearly report on small-holdings should be issued.

11. EXPERIMENTAL SUB-COMMITTEE.

Announced that this Sub-Committee had met on the 14th October and a copy of the Minutes had been sent to each member of the Board. The Committee had held a further meeting on the 13th December, for the purpose of considering the Estate Estimates for 1933, as well as Manufacture Experiments.

Announced that Mr. R. H. Horne of Messrs. Forbes & Walker had accepted the invitation to serve on the Experimental Committee.

The Chairman's action in inviting Mr. I. L. Cameron to serve on this Committee was confirmed, as also was the appointment of Mr. Jas. Forbes (Jnr.).

It was announced that this Committee hoped to meet every two months.

12. TEA CIDER.

Dr. Gadd said that experiments were still being carried out and he had found that satisfactory brews could be obtained by using cultures of two organisms only.

In reply to a remark made by Mr. Stewart, he stated that provided the cider were bottled at the correct time the cultures did not deteriorate, but if a brew were allowed to become acid before bottling the cultures did deteriorate.

13. PUBLICATIONS.

Announced that as a means of economy, the number of Publications had been reduced from 1750 to 1650 copies.

The Meeting terminated with a vote of thanks to the Chair.

A. W. L. TURNER,
Secretary.

FACTORY FIRES.

Our attention has been drawn to the following observations of a planter and visiting agent of considerable experience:—

"I think it would be of interest to you to know of an experience I had in our Factory a few days ago.

"The time was about 7 a.m. when I noticed a cooly hurriedly shutting windows, and on enquiring as to the reason was told that sparks were coming from the D. D. Sirrocco chimney. I looked out and large quantities of sparks which almost amounted to a burning debris, were floating outside the Factory, and being driven towards it by the prevailing breeze, so that the precaution taken by the Staff in closing the windows was most necessary.

"The cause of these 'fireworks' was that Dry Tea prunings were being used as kindling wood in the stove of the D. D. Sirrocco. Needless to say I have given orders that this class of kindling is not to be used in future.

"I bring this to your notice as it, I think, possibly explains a good many fires which have taken place early in the morning. I have received from Mr. X—— and other Engineers, elaborate reasons regarding the defects of Stoves and so forth, but I should not be surprised if an incident such as I have described above, is not accountable for a percentage of the fires.

On a Tea Estate there is no handier kindling wood than Tea prunings and had I not had an ocular demonstration of the danger attached, I should still continue to use them. The 'sparks' they cause really amount to glowing embers of wood, floating in the air".

[Further comment appears unnecessary.—C. H. G.]

FACTORY EXPERIMENTATION.*

C. H. GADD, D. Sc.

The methods used in the manufacture of Ceylon teas have been evolved from experiments carried out in a large number of factories over a long period of time, and great credit is due to those planters who by investigation and experiment have gradually evolved the methods in use today. The methods employed for experimentation have been necessarily empiric, and the question arises whether similar experimentation is likely to carry us much further along the road of knowledge and towards improvements in manufacturing methods.

Empiric experiments are less likely to lead one astray so long as the differences resulting from the various treatments are tolerably large, but when small differences have to be determined more accurate methods of experimentation become necessary.

Most of us realise how differently a scientist designs a field experiment today from the manner he did it some years ago. Then, one had a single plot under each treatment and any differences in yield were ascribed entirely to that treatment. That was all right so long as the difference resulting from the treatments was big, such as might occur when testing the yield of a manured plot against a no manure plot. But as soon as the scientist was called upon to determine whether one manurial treatment was better than another, when a difference of 5 per cent or less was of vital importance, he found that the simple method of single plot experimentation would not work. He thereupon set to work to determine why that simple method did not work, and to devise methods which could be relied on. Those methods are continuously being improved. They may appear extremely complicated to the layman but does that matter? It cannot be expected that complicated problems can always be solved by simple methods. If one calls in a scientist to help solve a problem he must be allowed to use his own methods and tools.

* Based upon an address delivered to the Sabaragamuwa Planters' Association on April 28th, 1933.

The field experimenter has one great advantage over his colleague in the factory; he can determine any actual differences in the yields of his plots accurately by means of a balance, but what is our factory experimentalist's criterion? He must rely upon the personal opinions of one or more tea experts, or upon a vagarious market for judgment.

It is an easy matter to distinguish a good from a bad tea, but it is a matter for an expert to detect the difference between teas differing but slightly in quality. Minute differences in quantity can be accurately determined and measured, but there is no infallible test for quality, nor is there a rigid standard by which it can be measured. There is, therefore, no cause for suprise that rigid agreement cannot be found in tasters' reports. We are accustomed to divergent views from literary and dramatic critics, but they do not have to appraise the books and plays they review in terms of sales and box office receipts. The tea taster, however, when used as the criterion of a factory experiment, is expected to state which is the better of two teas and to evaluate the difference. It is evident, therefore, that there can be no rigid and infallible measure of the results of a factory experiment, and this fact has to be kept in view. Although the tea taster is not infallible, as he would be the first to admit, he is the best criterion available, and great credit is due to him for his skill and endeavours to assist in the improvement of tea manufacture.

The real test of an experimental result is that when the experiment is repeated similar results are obtained; the frequency with which similar results are obtained is a measure of its accuracy. It is extremely difficult to repeat a factory experiment. An experiment carried out today frequently cannot be repeated tomorrow. Tomorrow's leaf will probably be of a different age from pruning, there may be a slight change in atmospheric conditions with the result that withering will take longer, or the leaf will not be withered to the same degree, the temperature of the rolling room may be higher, and so on. It is extremely difficult to reproduce exactly the same conditions, and such changed conditions constitute a reason why different results are frequently obtained from what are intended to be similar experiments.

The lack of uniformity of results is one of the reasons why we are asked if we have tried this, that or the other in the Tea Research Institute Factory. It would be very difficult to name experiments which have not been carried out in some factory at some time or other. The effects of varying the time and degree of wither, the pressure during rolling, the time of fermentation, etc., and the many combinations of these factors must have been tried over and over again. But there can have been no absolute unanimity in the answers the experiments gave, else there would be no divergent opinions on the various aspects of manufacture now.

A large number of experiments have been carried out in St. Coombs factory, and very many of them have been carried out on lines similar to those used in estate factories. These experiments have been necessary to meet the great demands for advisory work. We can rightly claim to have achieved a somewhat increased degree of accuracy owing to special facilities and the keeping of accurate records, but we have not yet achieved the desired degree of accuracy. Improvements in the technique of factory experimentation have still to be devised, but continuous efforts are being directed towards that end.

Teamaking is at present more an art than a science. There is a huge fund of information on the subject, but it is not all to be found in books. It exists in the minds of experienced planters and tea makers, but it has not been completely standardised. If the why and wherefore of each operation could be definitely expressed and the effect of environmental conditions clearly stated, improvements in the method of manufacture and in the design of factories and machinery would come apace.

For example, one of the few points in manufacture on which planters are unanimously agreed is that a natural wither gives the best results. What then is a natural wither? To state that it is a wither obtained by merely opening the loft windows, and without the use of fans or heat, is not to define it. The conditions which allow of a natural wither would have to be defined in terms of temperature and humidity If the optimum conditions for withering could be stated in definite terms, that air moving at a certain speed, having a certain

temperature and a definite humidity to enable the leaf to be brought to a stated degree of wither in a given time is necessary to give the very best result, it is not beyond the ingenuity of engineers to install in the factory apparatus which would give these conditions every day of the year. Moreover, if it were known that one set of conditions are required for quality leaf and another for rush teas, then arrangements could be made to switch on whatever conditions may be desired at any particular time.

But can anyone state exactly what those optimum conditions are? It is undoubtedly part of the duties of the Tea Research Institute to determine such points, and the why and wherefore of the various operations on manufacture. It is only by what may be termed 'fundamental' research that such information will be obtained. The chances of a really fundamental new discovery by random experiment or purely speculative theorising are well-nigh negligible. The necessity for fundamental research is imperative. The resources of science will have to be fully drawn upon and scientific methods will have to be applied. Instead of becoming less scientific as one of our critics at the last Conference at St. Coombs would have us be, we shall have to become more scientific, if the Institute is to serve the purpose for which it was founded.

I need hardly remind you that the Institute is being asked to obtain by means of research, information which has so far eluded a very wide awake, observant, planting community. The problems confronting the scientific investigator are not simple; only a few of them have been indicated here. The work must necessarily be slow. Not only has the most accurate means of measuring the results of factory experiments to be ascertained, but methods and apparatus have to be designed to extract the information necessary to speed on progress.

MARKET REQUIREMENTS.

R. H. HORNE

In considering market requirements and attempting to give any guidance in meeting them, it has to be remembered that the Tea Trade is an old and conservative institution. Certain demands have been created during years of trading; a certain type of tea has been established in particular countries, or even districts and has remained in favour for years. It is, therefore, obvious that any attempt on the part of producers to force a particular type of tea on the Trade is likely to meet with failure. The manufacturer of tea has to cater for his market, in the same way as any other manufacturer.

The Tea Trade, however, is not selling to one particular community, nor filling one particular demand. Tea now goes to every quarter of the globe and it is therefore not surprising that there is a great variety of demands; what may be an excellent tea for one country or district may be unsuitable for another. There are, however, generally accepted universal standards for tea, which, with an occasional exception, rule the prices of tea.

These standards can be roughly classified into the desirable and undesirable qualities. The desirable qualities are good, black, well twisted leaf, tip, even grades, quality, colour, strength and flavour; all to be aimed for when obtainable. The undesirable qualities are naturally their antitheses; poor leaf, stalk, thin liquor, taints, etc.

Few teas can be expected to combine all the good qualities, and where some of these factors cannot be expected it is advisable to concentrate on the remainder. Thus, on a low-elevation estate, where it is impossible to obtain quality and flavour, it is essential to aim for colour and strength, with good appearance; such aids to flavour as rapid and hard wither and light fermentation are best left alone.

For medium and high-elevation estates, excepting those above say 4,000 feet, the problem of whether to go for quality and flavour or strength and colour is a difficult one. Each estate must be ruled by local conditions and by the prices it commands.

Where prices are consistently good in comparison with neighbouring estates, the teas are probably supplying a particular market demand, and to make an alteration would be a dangerous gamble. In cases such as these, it does not follow that an improvement in the tea from a general standard would result in improved prices, as it may mean the loss of an established market. It is an unfortunate fact that realized prices are not always strictly relative to the accepted ideas of merit.

The problem therefore, which confronts the Superintendents and Agents of these estates is whether to aim for quality, or colour and strength, or a judicious combination of all. Superintendents may have been told that their teas lack quality and colour. This criticism is not of much assistance, as apart from correcting definite faults in manufacture, it may not be possible to increase both quality and colour in the particular type of leaf coming into the factory for manufacture. A more helpful report would be that the teas are poor in quality and colour, and that one or the other should be aimed for in a greater degree. The best way of deciding the point is to experiment with two contrasting forms of manufacture.

With medium and medium high grown estates, on the average, only three or four months of the year are favourable for the production of flavoury teas, and somewhere between 60 to 65 per cent of the crop is produced during the non-flavour periods. Therefore, under normal market conditions, the safest course for these estates is to make useful coloury teas with as much quality and "sweetness" as possible. Raw greenness should be studiously avoided. Greenness in the infusions is not a fault, as long as it is not a dull greenness. Greenness in the liquors is an undesirable feature, unless it is accompanied by flavour or pungency, of which it is often an essential adjunct.

Whatever the elevation of an estate, good appearance is of some value, and in low and low-medium estates is of importance.

The preservation of tip is an art which has largely been lost sight of. Tip, particularly in teas from lower elevations, is a distinct asset. The usual receipt for the production of tip is light rolling for the early dhools, but probably as much tip is lost owing to hard sifting and faulty firing as is ever conserved by a light rolling programme.

Probably the greatest factor dividing market requirements is that of grading. However good the value and attractive the quality offered in say, pekoes, a blender using B.O.P.'s in his packets will not change his buying, and under opposite conditions the same applies to a buyer selling a leaf blend. Therefore an increase in the sale of broken blends without a corresponding increase in leaf blends creates a relative stronger market for broken grades. This varying demand can be catered for, but the tendency has been if anything, to make too many changes in endeavouring to meet these demands, resulting in a glut of a particular grade. Very often satisfactory prices for a particular grade have led to an increase in the percentage of that grade, with a consequent lowering of the standard. Quite recently this has been illustrated in the production of excessively large percentage of B.O.P's. As the market then had too many B.O.P's with a doubtful right to the title and as there was a consequent reduction in the quantity of the true grade B.O.P's, the latter were the grades to benefit most by the change.

The question of percentage of grades is chiefly an economic one. While considerable change can be made in grading by altered sifting and cutting, this method can only increase the percentage of a grade at the expense of the standard of that grade or of some other grade. Frequently, however, general improvement in grade percentage can be achieved in the rolling room.

Turning once more to the question of liquors, conditions in Ceylon are such that in favourable weather, medium-elevation estates produce better quality than the high-elevation estates can turn out during the monsoon months. In spite of this large seasonal variation in quality, the majority of estates maintain a constant system of manufacture throughout the year, and a Dimbula estate may be discovered aiming for quality and flavour during heavy monsoon weather and a Dolosbage place, during a cold and dry February, concentrating on colour and strength. Under such conditions the best is not being got out of the leaf.

While teas sell well all the year round, they are probably filling a special market demand, and no variation in manufacture is necessary or desirable. In other cases, however, where teas are

selling strictly on their merits, judicious variation of manufacture to suit natural conditions is called for.

The alteration of manufacture, however, necessitates great care, and again market requirements are worthy of study. Good quality may be obtainable, but the question arises for a medium estate, is it worth losing colour for quality? This depends on both the amount of quality and the market demand. Unless some idea of the degree of quality can be conveyed to someone who is in touch with the market, the most desirable type of manufacture may be missed.

A fact that is not generally recognised in Ceylon is that the quality of the Indian and Java crop has a bearing on the demand for Ceylon tea. A good quality Indian season may mean a poorer demand for flavoury and pungent Dimbula and Uva teas. A thin and "rainy" crop from India will probably make for a good market for coloury Ceylon tea. These are points which chiefly affect estates selling in London, and advice should be sought in that centre.

To produce the best type of tea to suit requirements, and in consequence to realise the best prices, is only possible by the closest co-operation between the Superintendent and his Agent. The average stereotyped report is admittedly of little assistance in determining any necessary alterations in manufacture, but is not as a rule intended to indicate the necessity for such a change. If there appears to be a definite fault in manufacture, this would be commented on separately. If a change in manufacture is considered necessary, this is a matter of some moment and would be the subject of a special letter or comment. The next step would then be experimental manufacture.

While it is easy for the tasters to say where a tea is undesirable, it is difficult for him to say what is wanted, and at the same time to make reasonable allowance for what is unattainable. All teas, even the best, would be improved if they had more colour, quality, flavour and better appearance, provided the increase of one did not diminish some other. Undoubtedly the best way is for the Superintendent to send samples of various different systems, accompanied by full details of conditions of manufacture. The latter is important, as without them, both the samples and the resulting report may be misleading.

One word regarding experiments and experimental samples. The experiment should be very carefully carried out and as a rule only one change should be undertaken at a time. The leaf used should not only be leaf taken into the factory at the same time, but should also be bulked before withering. Every step of the manufacture should be identical except the one alteration. Firing presents a difficulty in this connection, and if two dryers of the same make are not available, it is best to load the trays of a dryer alternately with standard and experimental manufacture, taking care to "tab" each load. Any Superintendent who has personally undertaken an experiment of this nature will realise how important personal supervision is even to the final stage of sealing and marking samples, particularly the latter. Tasting samples should be at least a quarter of a pound each.

The variation of manufacture to suit market requirements is undoubtedly frequently necessary, but should on no account be undertaken without definite information of the type required from a well-informed quarter and certainty that the required standard can be attained.

ON THE THEORY OF WATER EVAPORATION AND ITS APPLICATION TO WITHERING AND DRYING OF TEA.

SVEN STRÖMGREN.

During the process of water evaporation, changes take place continuously both in the condition of the vapour and in the condition of the body from which the water escapes.

More important than the condition of the vapour is the condition of the body which is to be dried. Whatever method may be applied to study a process of this kind, it must aim at a disclosure of the phenomena concerning the body exposed to the drying action. In order to limit this discussion, I shall deal only with bodies of vegetable nature and of a type similar to the tea leaf.

It is known that the drying of a piece of wet cloth can be achieved by allowing air to pass over it, even if the air has a very high degree

of humidity but is not saturated. On the other hand, if fully fired tea be soaked with water and exposed to humid air, it will dry only to a certain extent, and a comparatively big amount of water will be left in the leaf. Such a residue can be dried off by passing a *very dry* air over it. From this, one may conclude that bodies behave in two different ways during drying, and in what follows I shall term a body similar in behaviour to the cloth above, as a "wet" body, and one comparable in behaviour to tea, as a "hygroscopic" body.

A body at a certain degree of moisture may behave as a "wet" body, whereas at a lower degree it may become "hygroscopic". This is actually what happens with tea leaf, although the passage from the "wet" to the "hygroscopic" state is not very marked.

Every wet or hygroscopic body exerts a pressure termed the elastic force of water vapour. In the case of a "wet" body this elastic force depends upon the temperature only, while in a hygroscopic body it is also influenced by several other factors, such as capillarity, concentration of solutions, etc. The hygroscopicity of tea leaf thus depends upon the temperature, the structure of the leaf and the concentration of the juice. The elastic force of vapour in a hygroscopic body is always lower than in a "wet" body at the same temperature. A "wet" body always has an elastic force of vapour equal to that which would exist in air were it saturated at the same temperature. The degree of hygroscopicity may, therefore, be determined by the difference in elastic force of vapour inside the body and the force in saturated air at the same temperature as the body.

An important factor in all evaporation processes is the *rate* of evaporation, i.e., the weight of the water which is evaporated from a square inch of the surface of the body per second. This rate depends firstly, upon the difference in elastic force of vapour between the body and the surrounding atmosphere, and within practical limits it is proportional to this difference. Secondly, it is influenced by the atmospheric pressure, and is approximately inversely proportional to the barometric pressure. Thirdly, it depends upon the amount of air that passes over the body per second and the area of the surface of the body exposed to the air. It is thus influenced by four factors in all, and I would like to stress that not one of these factors is either

the dry temperature of the air or its relative humidity, the latter being the ratio between the elastic force of vapour in the air present and the elastic force of the air when saturated at the same temperature. In further stressing this point, one may say that neither the relative humidity nor the temperature of the air, measures directly the capability of drying which the air may possess; to use these values to determine the drying capacity of the air to which they refer, one requires a table to find out actually what water carrying capacity the air has left.

In an evaporation process, the temperature of the body is, however, of great importance. We all know that certain materials have to be dried at low temperature, and unfortunately tea is of this type. On the contrary, certain materials can be dried regardless of temperature. If a material during the whole drying period is a "wet" body, its temperature will remain practically the same as the wet bulb temperature of the surrounding air. If at a lower moisture content, i.e., when partially dry, the material becomes hygroscopic, its temperature will have to be raised above that of the wet bulb thermometer, otherwise evaporation will cease. The drier the hygroscopic substance becomes, the higher one must raise its temperature above that of wet bulb. If, therefore, the temperature of the substance must not exceed a certain limit, the wet bulb temperature of the surrounding air may have to be lowered in order that the material can be dried to the desired degree without raising the temperature of the body.

As tea leaf at the beginning of the drying process behaves like a "wet" body, it has a temperature approximately equal to that recorded by the wet bulb thermometer in the surrounding air, but during the latter part of the drying (when the leaf becomes hygroscopic) its temperature will rise and approach that recorded by the dry bulb thermometer. In actual tests, one finds that the rise in temperature of the leaf mainly takes place in one section of the dryer or on one tray of the dryer. In reality, tea leaf is a hygroscopic substance the whole way through the dryer, but from a practical point of view it deviates in behaviour so little from that of a "wet" body in the beginning of the drying, that we may consider it during that period as "wet". Careful measurements of the temperature of the tea inside a dryer have shown that the tea on the first three trays in a 4 ft. conveyor dryer very closely follows the wet bulb temperature, the deviation being not more than 5 per cent.

Another important aspect of tea drying is the variation in elastic force of vapour inside the tea leaf. The writer has tried to carry out an investigation along this line with some success, but he does not intend to deal fully with this matter here. I should like to make a few statements which, however, must be taken with certain reservations, as my experiments on this point are not complete.

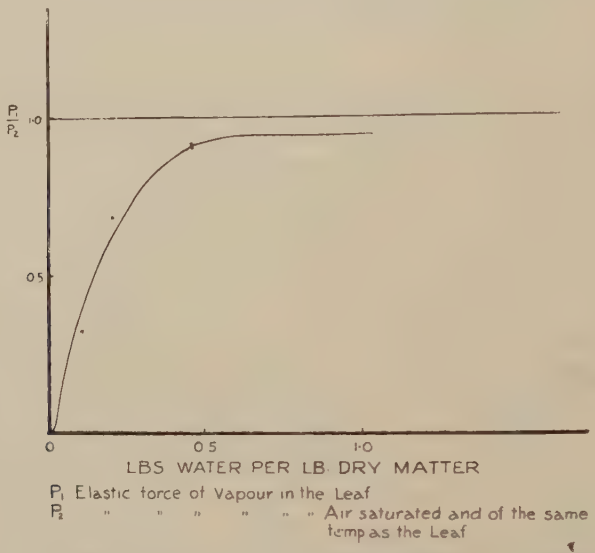

P1/P2
1·0
0·5
0
0·5
1·0
LBS WATER PER LB. DRY MATTER
P1 Elastic force of Vapour in the Leaf
P2 " " " " " " Air saturated and of the same temp as the Leaf

FIG. 1. *CURVE SHEWING THE VARIATION OF ELASTIC FORCE OF WATER VAPOUR IN TEA LEAF DURING HYGROSCOPIC PERIOD*

Anyone can find approximately the temperature of the tea leaf during the first part of the drying process by measuring the wet bulb temperature of the air inside the dryer, and it is then easy to determine the corresponding elastic force of vapour from a table. But I can give no rule to determine the elastic force of vapour during the hygroscopic period. The magnitude of the variation may be from 1 to 100, i.e., the elastic force of vapour in the fully fired tea at the moment it leaves the dryer may be one-hundredth of the force in air saturated at the temperature of the tea. As the tea cools after leaving the dryer, the elastic force decreases with the result that the tea picks up moisture out of the air. This absorption of moisture is at first so rapid that the moisture content in the dry leaf may increase several per cents in a few minutes.

The variation of elastic force of vapour in tea leaf at a constant temperature of approximately 100°F. is given in Figure 1. It can be seen from this graph that the change from the "wet" to the

hygroscopic condition takes place when there is about 30 per cent moisture left in the leaf. The actual shape of this curve will probably vary with different types of leaf, such as young leaf or old leaf, tippings, and probably also with high-grown and low-grown leaf.

During the withering also, the leaf becomes more and more hygroscopic towards the end, although the degree of hygroscopicity is small compared to the degree reached in the drying process.

As in case of drying, the rate of evaporation during the wither depends upon the following four factors only:—

(1) The difference in elastic force of vapour between the leaf and the air.

(2) The barometric pressure.

(3) The volume of air that passes through the lofts per second.

(4) The surface exposed by the leaf to the air.

Of these factors, the first and the third are of equal importance, that is to say that a big amount of air and a small difference in elastic force of vapour are, from the drying point of view, equal to a small amount of air and a bigger difference in the elastic force of vapour. As in the case of drying, the temperature or the relative humidity of the air is of no direct interest from an evaporation point of view, especially when the withering is carried out between reasonable temperature limits, say 50 to 100°F.

So far, I have tried to derive the physical laws of water evaporation from knowledge which is common to most planters, the drying and withering processes having been used to illustrate the laws. In the following pages I shall try to describe the two processes more completely, but it may be necessary to repeat some of what has already been written in other connections.

The Physical Process of Tea Drying.—The curves given in Figure 2 show the physical relations between the air and the tea during a drying process. On the ordinate are plotted the temperature and the moisture contents, while on the abscissa is given the time in percentages of the total drying time. It is not intended that these curves should give more than a general idea of the process.

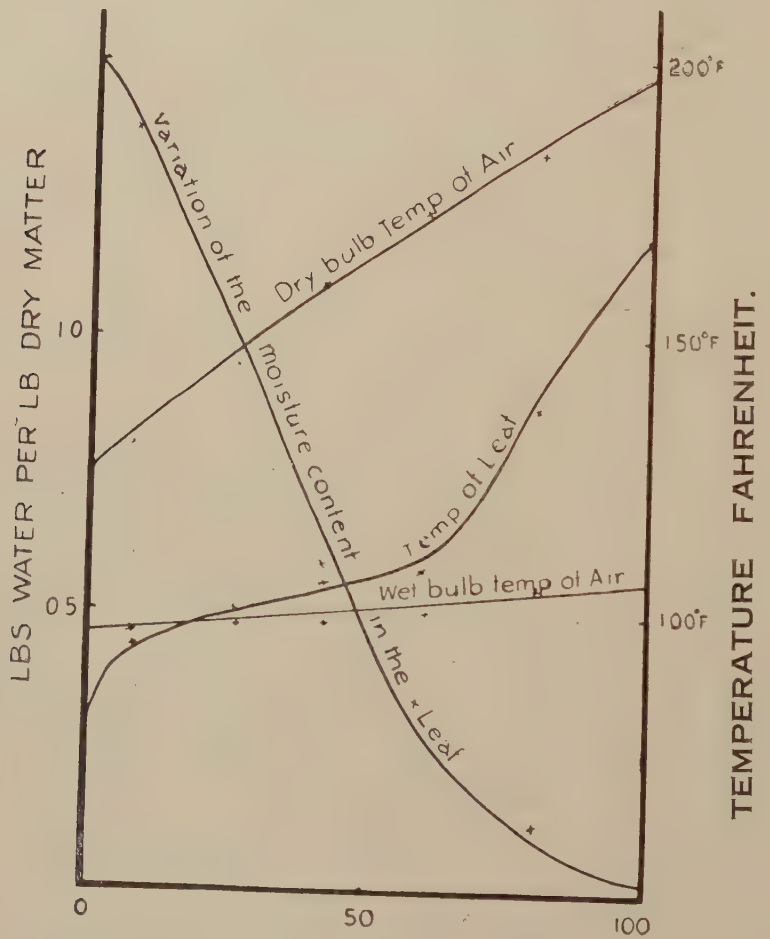


FIG 2. CURVE SHEWING CHANGES IN THE CONDITION OF THE LEAF & THE AIR DURING DRYING

The water content of the tea as well as that of the air is not counted in percentages, but in the amount of water per pound of dry air and dry tea respectively. These curves refer to a drying process where the air travels in an opposite direction to the leaf, such as occurs in a tilting tray type. In a dryer of the conveyor type, such as an E.C.P. or Empire dryer, where this is not actually the case, the process of drying is more difficult to study.

From these curves one finds that the wet bulb is practically constant through the whole drying process, while the dry bulb of the air alters considerably.

When drying tea, the question of quality has always to be borne in mind, but the relationship between quality and drying has not yet been completely elucidated. One may, however, consider that the tea leaf in the dryer should not exceed a certain temperature at any time and also that the leaf entering the dryer should be exposed to a rapid drying action in order to prevent further fermentation.

Like chemical processes in general, fermentation is mainly influenced by the temperature of the leaf and its moisture content. It is probable that the fermentation proceeds most rapidly at a certain temperature, and that its rate diminishes when the temperature rises or falls from that optimum. It is probably also correct that fermentation proceeds more rapidly with a solution of certain concentration in the leaf, and that with a more concentrated or less concentrated solution, the rate of fermentation falls off. The problem of stopping fermentation or preventing stewing (whichever term is used) is, therefore, to balance the two factors, the temperature of the leaf and the dryness of the leaf, in such a way that the rate of fermentation is sufficiently decreased at an early stage of the drying process.

Much has been written about temperatures of the air in the dryer which will prevent stewing. From a theoretical point of view and as stated above, the temperature of the air has no direct relation to either the dryness of the leaf or the temperature of the leaf. The only thing that can give us a clue whether the dryer is working properly or not, is the difference between the elastic forces of vapour in the leaf and in the air at each point in the dryer; in order to simplify matters later on, I will here introduce a term and call this

difference the "drying potential". In order to find out whether the rate of evaporation and the temperature of the leaf combine to prevent stewing or stop fermentation, one must therefore study the drying potential of the air, and the simplest method will be to determine the drying potential of the air as it leaves the dryer.

The prevention of stewing can be achieved by keeping a certain drying potential in the exit air provided that other conditions in the dryer are normal. If the air escaped from the dryer fully saturated, it would mean that the tea on the top trays, while carrying a fair amount of moisture, was undergoing a very slow drying action and being kept at a comparatively high temperature for a considerable time. The result would be similar to that of increasing the temperature in the fermenting room.

In tea gardens at high elevations, however, for tea drying purposes the climatic conditions of the air, as regards the elastic force of vapour, vary very little, provided that the inlet temperature of the air is kept constant within reasonable limits. The dry bulb temperature alone gives a fairly good measure of the drying potential and so we reach the old statement in the literature that a temperature of 120°F. at the exit will prevent stewing. This statement, however. only holds good if the wet bulb remains constant. To take an example; if tea was to be dried at a low elevation *with the air entering the stove at a temperature of 100°F. and fully saturated*, this tea would be badly stewed if fully dried with a temperature of 120°F. at the exhaust. To prevent stewing in this case, the volume of air must be increased to such an extent that the exit temperature reaches somewhat near 150°F.

As previously mentioned, a low barometric pressure helps the water evaporation, and one may therefore expect less difficulty in preventing stewing at high elevations.

There are mainly three means by which one can control the drying potential in the exhaust: (1) by varying the volume of air and this is probably the method which is most usually adhered to; (2) by varying the thickness of the spreading or the speed of the trays, the first method being the more sensitive one; and (3) (which so far as I am aware has never been used in tea drying) by regulating

the wet bulb temperature of the incoming air, or in other words, by regulating the elastic force of vapour in the air that enters the dryer. This latter method is probably the most rational one, because variation of the air volume very often disturbs the distribution of the air in the dryer, whereas variations in the amount of leaf fed into the dryer upsets the out-turn of the machine.

If the conditions of the air that enters the drying chamber proper is constant as to temperature, humidity and barometric pressure, the condition of the exhaust will vary with the amount of evaporation that takes places inside the dryer, i.e., with the amount of water that passes through the dryer per unit of time, or still better with the moisture content of the incoming leaf. If one has decided upon a certain rate of evaporation and the temperature at which the tea leaf is to be maintained during the first period of drying, he will have to regulate the condition of the expelled air in such a way that these conditions in the leaf are satisfied.

One very often hears the expression "case-hardening" used in conjunction with tea drying. I have several times purposely tried to produce this effect, but have so far only succeeded with a coarse bulk, and in order to do this the air has had to leave the dryer with a drying potential of ·4 in. of mercury or more, and with the trays running at maximum speed to avoid burning later on.

Before I enter into a discussion on the practical problem of regulating the drying process, I will deal in a few paragraphs with the second half of the process, i.e., after the leaf has become hygroscopic.

It may be seen from the curves in Figure 2 that the temperature of the tea leaf during this period rapidly increases while the decrease in its moisture content is comparatively slow. While the temperature of the leaf during the first period must always be considered in conjunction with its dryness and rate of evaporation, the temperature of the leaf alone during the later period is of importance. This is because the temperature of the leaf gradually approaches that of the dry air, and the leaf, having a low specific heat, may get its temperature raised more quickly should the drying not be properly looked after. It is therefore of importance that during this period the leaf

must be exposed to air with low elastic force of vapour. This is always the case in the ordinary drying process, where the air travels in an opposite direction to the tea. Where one deals with leaf with big moisture contents, however, it may be advisable to divide the drying into two steps and carry out the first period down to 30 per cent moisture content in one dryer and to finish off in another dryer, in which case the latter process may have to be controlled in a different manner from the first.

In this connection, I should like to mention a statement which one very often hears planters put forward as a reason for so-called double firing, and that is, that the double firing increases the capacity of the dryers. This is not the case. On the contrary, double firing considerably decreases the amount of water which may be evaporated in the two dryers combined, and consequently the out-turn of tea from the two dryers also when compared with the out-turn at full firing in both machines. The only reasons for double firing are, therefore, high moisture content in the leaf and also in the atmosphere, which necessitate a separate control of the second period of the drying to prevent the leaf from reaching too high a temperature. With double firing one can also reach a lower moisture content in the tea, but it is possible that the chemical processes, which take place during the latter part of the drying, proceed in a slightly different way. Whether this is beneficial or otherwise I do not know.

Dryers consisting of two chambers in which the condition of the air can be individually controlled are in use for materials other than tea. For certain types of vegetable matter in S. America one uses a dryer consisting of a revolving drum, which for the first period is worked with heated air, whereas for a later period it is worked with cool air which has been dried over a water absorbing substance. By this method one is able to complete the drying process without raising the temperature of the material itself to such a high degree as would be necessary if the whole of the drying was done with hot air. However, I believe it has been proved that tea has to reach a certain temperature in the drying in order to "fix" its qualities.

When the tea leaves the drying chamber, it still contains a certain amount of moisture. This moisture content depends upon various factors such as the amount of air used per unit of time, its drying potential and the type of leaf such as fine dhools and bulk. In general, one may say that the higher the drying potential, the drier the leaf will be. The element of time, however, is in this respect of more importance, as the tea will become drier if it is exposed to the air longer during the later period.

If tea is kept in a container with air, it finally reaches an equilibrium when the moisture content of the tea corresponds to the elastic force of vapour in the air. At the same time, the tea will acquire a temperature equal to, or just below, that recorded by a dry bulb thermometer in the air. These conditions, however, are never reached in the dryer where the tea always has a higher temperature than that one which corresponds to its dryness.

In practice, I have found that the drying potential of the exit air is a fairly good measure of the dryness of the outgoing tea, and this is particularly so with a dryer which is doing only the second firing. Therefore, if one can control the drying potential of the air leaving the dryer, one can also control the dryness of the outgoing tea.

(To be continued.)

SOIL EROSION.

T. EDEN.

Although the tea planting industry has a surfeit of new problems with which to deal at the present time, it would be a short-sighted policy to lose sight of such old-established questions as soil erosion. One frequently hears discussions on how best to maintain the capital value of estates which may, during a period of restriction, be relegated to a lower state than usual in both production and cultivation. No excuse should, therefore, be needed for returning to the consideration of the capital loss involved on estates through soil erosion.

It has recently been possible to make a study of the soil erosion work in progress throughout the world with a view to classifying the information available. Different groups of workers have approached the problem from different angles, because aspects that are of paramount importance in one place have only a subsidiary interest in others. Moreover, conditions of climate, soils and crops vary enormously. From such a jig-saw puzzle of information with many of the pieces, so to speak, still missing some idea of the resultant picture can nevertheless be obtained. It is proposed, therefore, to present a series of articles on soil erosion, each of which shall deal with a definite aspect of soil erosion waste and prevention.

THE MENACE OF SOIL EROSION.

One of the reasons why progress in soil erosion prevention is slow, lies in the fact that the cultivator who is primarily responsible for the damage is seldom in a position to assess the extent of the harm he is unwittingly causing. It is an unfortunate fact that, because the results are far-reaching, actually and figuratively, co-operation between interested parties is difficult to achieve. The losses from soil erosion and associated processes are by no means concentrated on the area that suffers in the first instance, and by the time the whole tale is told, the bill for potential loss to all concerned may be many times that of the original loser. By way of introduction it will not be out of place to indicate how serious the gross damage may be.

There is no doubt that the cultivator is a heavy loser, although he may not know it. In the United States the National Conservation Commission found that the loss of production on upland farms amounted to from seven to ten per cent of the normal. This figure compares roughly with the assessable loss due to disease in crops. Work on crop diseases has developed to a high degree of specialisation all over the world, yet except in the United States, soil erosion work is the Cinderella of the agricultural and forestry departments.

In the wake of soil erosion come floods. Floods will be less likely if a large portion of the rainfall can be continuously absorbed by the soil and discharged slowly as springs at seepage points. The spread of agricultural enterprise has accentuated a problem that has always existed in some degree. The Mississippi floods of 1927 are calculated to have done three hundred million dollars worth of damage.

The rapid loss of enormous volumes of rain from the surface of the ground in the form of run-off, in many cases, causes underground water shortage subsequently. Springs and wells dry up because there is a progressive fall in the level of the water table. Whilst the agriculturist feels the effect in drought conditions for crops and stock, a complaint frequently voiced in S. Africa, the community as a whole feels the pinch later.

When introducing a Bill for forest conservation into the U.S.A. Legislature, the case of Los Angeles was quoted showing that soil denudation had so lowered the level of profitable water supplies near at hand that sources 250 to 300 miles away had to be tapped. Domestic and industrial water supplies must of necessity be steady in capacity, and the flow of streams supplying them is the deciding factor in providing stability; any large fluctuation in the ratio of high and low water level endangers continuity of supply.

The soil that run-off water carries with it adds further to the water conservation problem. Dams and reservoirs become rapidly silted up and lose their efficiency. Measurements have been made on thirty reservoirs in the south-west of the U.S.A. where silting up was found to be proceeding at an average rate of a foot per annum. It was calculated that in this instance the useful life of a reservoir was no longer than 15 years.

From the silting up of reservoirs the association of ideas naturally leads to the silting up of rivers. In so short a time as forty years the navigable reach of the Mississippi has been noticeably curtailed. Nearer at hand, the findings of the Kelani Valley Railway Commission point in the same direction.

There is yet another aspect of soil erosion in general that is not sufficiently emphasized, namely the creation of waste deposits. It is true that the eroded site loses its best soil. This must be so since this soil, besides containing the bulk of the nitrogenous organic matter, is also the most highly weathered; it is a true soil and not merely a collection of mineral fragments. Soil lost in run-off becomes in many cases completely denatured; the process may be pictured as follows. Before being subject to erosion the soil particles are of very different shapes and sizes and are held together in crumbs by the organic material that coats their surface. Prolonged suspension in moving water destroys the cementing layer. The particles come apart, and their ultimate fate depends largely on their individual size. As the disintegrated soil is carried forward in the stream, the heavier particles are deposited first as the stream loses speed; these are largely unweathered mineral fragments. Later, smaller particles come to rest, but it is readily realised that what is happening is a progressive sorting out of particles into classes determined by their size and the velocity of the stream. One might say it was a winnowing of soil particles by water instead of air. These layers of mineral particles, which no longer deserve the name of soil, show no crumb structure and are physically and chemically unsuitable for really healthy plant growth. The finest particles of all are often carried out to sea or deposited in delta formations saturated with salt so that even they, the richest in chemical constituents, are no use to agriculture without costly reclamation processes. To quote an example of how waste deposits have been laid down by erosive action, in the Piedmont district a fertile black soil is rapidly being converted into an infertile sand several feet thick.

It is not contended that all these aspects of soil erosion and run-off damage occur in such striking magnitudes in Ceylon, but even in modified forms the economic loss is great. Estate agriculture cannot entirely disclaim responsibility for floods and water shortage, and waste deposits when the underlying causes are viewed in their proper perspective.

RESTING THE TEA BUSH.

F. R. TUBBS.

The advent of a scheme of restriction has made the various methods of reducing yield the subject of wide-spread interest, everyone seeking to prepare in advance the scheme which will prove most advantageous in his particular district and conditions. Some estates may consider it advisable to buy the export permits of other less favourably situated estates and so continue normal production. Others will manufacture a fraction of their potential yield, while some may cease production completely. The two latter classes will seek to combine restriction with measures that will improve the health of their bushes.

An obvious method of reducing yield is to cease plucking certain portions of the estate. The "resting" of the tea in this way has definite effects upon the growth of the bush, and it is advisable to understand these in order that the process may be applied in such a way as to produce the greatest possible beneficial effects upon the health of the tea, and thereby, indirectly, upon the capital value of the estate.

The tea bush, as normally cultivated, manufactures in its leaves the food necessary for its life and growth. This is done by the absorption of carbon-dioxide from the air, and its subsequent manufacture into materials that can be used to build new tissues, by the aid of the cells in the leaf containing the two green pigments, collectively known as chlorophyll. The uses to which the manufactured material is put are diverse. Some is used immediately to maintain the tissues of the leaf, some is translocated to other organs of the plant that are in need of food, while the balance above the daily requirements of the bush is laid down as reserve material which may be drawn upon when required.

When bushes are left unplucked, it will be noticed that during favourable weather, new shoots are produced which may grow to a length of eighteen inches or more before growth ceases and they become "bhanji". A shoot then remains in that apparently dormant condition until the surrounding environment stimulates a fresh burst of growth. But it must not be assumed that the shoot is "dormant" in the sense that trees of temperate climates become dormant in winter. The young shoot is initially produced at the expense of that fraction of the food, manufactured by the leaves already upon the bush, that would have been stored as reserve had it not been diverted for building the shoot. As the leaves borne upon it expand they commence the process of manufacture, and thereby bear a portion of the burden of producing new leaves and stem at the apex of the shoot. When the shoot ceases active elongation, the whole of its manufactured material, save that required for its maintenance, becomes available for the remainder of the bush, the main bulk in all probability being laid down as reserves. The operation of plucking alters this state of affairs considerably. The removal of the two leaves and a bud before the leaves have reached maturity has two results. Firstly, the bush is deprived of return for the material expended in their production, and secondly, it is stimulated to produce another young shoot, which is in turn removed. It is obvious that the rate of production of new reserves must be reduced by this process, and were it not for the activities of the leaves that are left upon the bush in plucking, the bush would eventually perish of inanition.

The foregoing account also shows that in the forcing climate of low elevations in Ceylon, the rapid production of flushes of new shoots must place a heavier burden upon the manufacturing leaves of the bush than is the case in the climate of higher elevations where yield is less. In consequence, a bush at a low elevation has less chance of accumulating a satisfactory reserve before the next pruning than has one situated at a higher elevation. The economic effects of this difference only become visible when pruning is undertaken, the outstanding difference between high and low elevations being the amount of dieback that occurs at the latter, whereas it is almost entirely absent at the former. This has been shown to be

due to the fact that at low elevations the reserves accumulated during a pruning cycle may not be large enough to supply the material for the production of new shoots from the pruned frame.

To what extent can restriction be utilized to obviate this state of affairs? An obvious method would be to ensure that more manufacturing leaves were left upon the bush, thereby enhancing the ability of the bush to accumulate reserves. This end might be obtained by plucking to, say, two full leaves above the fish leaf instead of one. The method is, however, open to the serious practical objection that the height of the bush would increase far too quickly, especially in the case of high jât bushes with long internodes. It cannot therefore be regarded as a satisfactory solution.

A second and more promising method is to rest the bush before pruning. This enables the bush to accumulate reserves in the manner already described for an unplucked bush. Poor areas and those that are known to suffer considerably from dieback at pruning should be rested for at least three months, the period decided upon for healthier areas being dependent upon the amount of restriction that is necessary. By employing this method, damage to the frame of the bush after pruning is avoided, but it is open to the objection that it is the leaf from the oldest areas that is being discarded. The average age from pruning of the fields in plucking need not, however, be seriously altered provided that resting after pruning is also adopted.

Resting before pruning is carried out for a different purpose from that for which resting after pruning is used. The former enables the death of portions of the old frame to be avoided, while the latter results in better growth of the new stems that are formed after pruning. The thickening of the lower portion of a woody stem is closely correlated with the growth of the apex and of the lateral branches. Therefore any process checking the free growth of a shoot will retard the thickening of its stem. Tipping is the first of a series of checks that is applied to the shoots throughout the plucking cycle. As a result, the thickness of the new stems produced upon a bush that is tipped and plucked in the normal manner is smaller than upon a bush that is rested after pruning. It was found

at St. Coombs that resting bushes for four months after the normal time of tipping resulted in an increase of 36 per cent in the weight per unit length of stem over that found for a normally treated bush, the measurements being made at the end of the period of resting. It will be seen that the two methods of resting are in reality complementary, each contributing to the production and maintenance of a sound and healthy frame.

The application of one or both of these methods to the weak bushes in otherwise healthy fields will be of benefit, although naturally no great restriction of crop will result from this alone. It should also be noted that in cases where severe methods of pruning are considered necessary for the renovation of the frames of the bushes in poor areas, restriction provides an opportunity to rest such areas before and after pruning more thoroughly than has been possible in the past.

In the case of estates having areas of young tea that have not been pruned, there will be a temptation to delay the operation longer than would normally be done. Such a procedure obviates the immediate expense of pruning, but it involves the centring of thick stems at a later date. This may be expected to result in damage, resulting from the infection of wounds by disease organisms, that will more than offset the temporary saving made. It is advisable to continue the normal methods of producing a spreading frame until the stage is reached at which the area would normally be brought into bearing. If the areas are then rested, the bushes can be brought into production whenever required, and in addition they will possess vigorous spreading frames capable of producing a high yield. Were the operations of centring and frame formation delayed, valuable time would be lost in bringing the area into production.

Where it is considered advisable to throw a whole estate out of production, it is desirable to spend rather more than the normal on the pruning of each field as it becomes due. Snags, knots and unhealthy branches can then be removed more thoroughly than has been possible on the reduced votes that have been current latterly. Having performed as thorough measures of bush sanitation as can

be afforded, the prolonged resting which follows will enable the formation of good new wood upon a basal frame which is in a much healthier condition than would have been the case had no cleaning up been done.

REVIEW OF THE WORK OF THE SCIENTIFIC STAFF.

The following review relates to the quarter ending 31st March 1933:—

The scientific work of the Institute has been restricted during the period under review owing to the absence of the Director on leave from February 7th, and to the illness of the Entomologist from February 23rd. The Biochemist was occupied mainly in rounding off his investigations and completing his records preparatory to retirement.

A Conference was held at St. Coombs on January 27th and a full report of the proceedings was published in the last number of *The Tea Quarterly*.

Twenty-nine consignments of diseased plants were received by the Mycologist of which the majority proved to be root diseases. Investigations into the biologic constituents of the ferment used for brewing Tea Cider have been completed, and a large number of cultures have been distributed.

Further experiments to determine the value of the addition of vitamins to the meal used for moth production in the Tortrix parasite breeding investigations have been started. As the meal used for moth production is subjected to heat before use, it seems possible that such treatment may have a detrimental effect on the food value of the meal, and that the addition of vitamins may have a beneficial effect. Accurate records are being kept of the out-turn of moths to determine this point.

Studies of the life-histories of the different species of nettle grub and their parasites have been continued. Numerous laboratory tests have been made with various insecticides but the diminution of the attack of these pests in the field has reduced the opportunities for field trials.

Records were made by the Physiologist of the numbers of Tortrix egg-masses found on the individual plots of the pruning experiment at St. Coombs from September to December last. Some of these plots were pruned in August 1931, others in December 1931, and April 1932. The incidence of Tortrix, as judged by the number of egg-masses collected from other parts of St. Coombs when these plots were pruned, was least during the September and April prunings and greatest in December. There would appear to be the greatest risk of reinfection, therefore, in the plots pruned in August and December as the moth lays her eggs only on mature leaves, whereas the plots pruned in April would largely escape infection as mature leaves would not be plentiful till the Tortrix attack was over. That this was actually the case is supported by visual observations at the time.

The records collected at the end of last year were examined to ascertain whether there was any difference then in degree of the Tortrix attack in the plots pruned at different times. The numbers of egg-masses collected were as follows:—August pruned plots 4,835, December plots 4,523 and April plots 3,513 from which it is evident that the attack was least in the April plots. Statistically no importance can be attached to the difference between the August and December plot results, but the attack in the April plots was significantly smaller.

It is of considerable interest that the plots which were least attacked, as judged visually, in 1931 were also least attacked when examined more thoroughly in 1932 although the plots are small and in close proximity to each other. It suggests that migration under certain circumstances is not rapid, and that eggs are deposited on leaves near the place the moths emerge from the cocoons; otherwise a more uniform distribution through the plots would be apparent in 1932.

These observations are distinctly suggestive that where fields are annually attacked by Tortrix, the moths which initiate the attack emerge in the field itself and are not necessarily brought in from an outside source. Support is given to this view by the fact that experimental plots, which were severely attacked in 1931, sufficient to warrant a regular 5-day egg-mass collecting round, were very mildly

attacked in 1932, whereas plots which were mildly attacked in 1931 and from which egg-masses were not regularly collected were more severely attacked in 1932.

The records were also examined to determine whether there was any relationship between the severity of attack and the method of pruning of the different plots. Methods of pruning which allow mature leaves to remain on the bush might result in heavier infestations in that the leaves themselves may already bear egg-masses at the time of pruning, or become receptacles for egg-masses soon after pruning. Clean pruned plots on that assumption are likely to be less severely attacked than those which are rim lung pruned or cut across. The numbers of egg-masses collected from these plots were as follows:—Clean Pruned 3,653, Rim Lung 4,051 and Cut Across 4,167. Statistical analysis, however, indicates that reliance cannot be placed on the observed differences and that more accurate experiment would be necessary to determine whether the hypothesis is true.

Routine plucking and recording of yields from the manurial and pruning experiments has been continued.

At the time when the technique of field experiments was under investigation the possibility of using intermittent weighed pluckings was examined by the Agricultural Chemist, and certain tentative conclusions favourable to the method were suggested. The data from the manurial experiment afford a much more stringent test than has hitherto been possible, and in view of the possible extension of sub-station work the method has been examined further. The results have confirmed the reliability of this method of conducting subsidiary experiments.

The programme of testing out promising green manures has been intensified; the nursery area devoted to this purpose is now over an acre in extent and some twenty varieties of tree, bush and cover crops have been planted. In addition, areas have been reserved for testing the effect of lopping at more frequent intervals on dry weight of crop secured and on the amount of nitrogen recovered.

Among the species, tests of special note are the following:—

Phytolacca dioica, an East African leguminous shade tree suitable for medium light shade, and alleged to be suitable for dry situations.

Hakea saligna, an Australian ornamental tree now being grown for wind belts in the higher altitudes of S. Indian tea districts, as an alternative to Grevillea.

In the Laboratory a number of modifications of technical methods have been tried out, and routine analyses in connection with advisory work have occupied the staff.

C. H. GADD,
Acting Director.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held at St. Coombs Estate, Talawakelle, on Friday, the 14th April, 1933, at 2-15 p.m.

Present.—Mr. R. G. Coombe (Chairman), the Acting Director of Agriculture (Dr. J. C. Hutson), Major J. W. Oldfield, C.M.G., M.C., O.B.E., Messrs. R. D. Morrison, I. L. Cameron, John Horsfall, Jas. Forbes (Jnr.), A. W. L. Turner (Secretary) and by invitation Mr. J. W. Ferguson, Dr. C. H. Gadd (Acting Director), Messrs. T. Eden, F. R. Tubbs and John A. Rogers (Superintendent).

Absent.—The Hon'ble the Financial Secretary, Col. T. G. W. Jayewardene, Messrs. B. M. Selwyn, G. K. Stewart, M.S.C., and D. H. Kotalawala, M.S.C.

1. Notice calling the meeting was read.

2. Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 15th December, 1932, were confirmed.

3. MEMBERS OF THE BOARD, T. R. I.

Announced that Mr. J. A. D. Finch Noyes and Major H. Scoble Nicholson, O.B.E., had resigned and the Ceylon Estates Proprietary Association had nominated Messrs. R. D. Morrison and I. L. Cameron to fill the vacancies.

Announced that Major Oldfield, C.M.G., M.C., O.B.E. was proceeding on furlough at the end of April and asked for leave of absence as from the 15th April. Leave of absence was granted and the Ceylon Estates Proprietary Association's nomination of Mr. D. T. Richards to act for Major Oldfield was approved.

4. FINANCE.

The Statement of Accounts as at February 28th was passed without comment.

Audited Accounts.—Copies of these Accounts were sent to each member of the Board under cover of Circular dated the 27th February, 1933, and were adopted by the meeting.

Auditors.—On the recommendation of the Finance Sub-Committee Messrs. Ford, Rhodes, Thornton & Co., were re-elected the Institute's Auditors.

Depreciation.—The Finance Sub-Committee's recommendation that Depreciation should be calculated in accordance with common practice and not on the prime cost basis was adopted.

Empire Marketing Board.—Announced that the Empire Marketing Board had paid the full grant of £1,000 sanctioned by them for the purchase of Experimental Machinery and a report had been sent to them with regard to the manner in which the Capital grant had been expended.

Nettle Grub Campaign.—Announced that it was no longer considered necessary to rent Blarneywatte Bungalow and the agreement had been terminated on the 31st March 1933.

In this connection the Acting Director suggested that the work of the Passara Station should be extended to include agricultural field experimentation and not be confined to Entomology, as at present Gonakelle Estate had promised, subject to the approval of the Proprietors to lend 10 acres, free of charge, for experimental plots. All Laboratory work could be carried out in the two Nissen huts erected last year. He added that if this suggestion were adopted the Institute would then have Up-country, Low-country and Uva Stations i.e., St. Coombs, Galatura and Passara.

The proposal was agreed to.

Tea Restriction.—It was agreed that Mr. G. K. Stewart, M.S.C., should be asked to do his utmost to obtain exemption for St. Coombs and be given power to take any steps he might consider necessary to obtain this end.

Sale of Gas Plant.—The Board endorsed the Finance Sub-Committee's confirmation of the Chairman's action in allowing the sale of the Willet Petrol Gas Plant.

Sanitation.—On the recommendations of the Finance Sub-Commitee an additional Rs. 200/- for the current year was sanctioned. This sum will enable the necessary works to be carried out and provide for efficient supervision of all sanitation work. The whole of the sanitary staff to be under the charge of the Estate Superintendent.

New Clearing Drains.—The Finance Sub-Committee's recommendation that an additional Rs. 194 - be allowed was agreed to.

Upkeep of Clearings.—The Finance Sub-Committee's recommendation for an additional grant of Rs. 390 - under this heading was agreed to.

Uprooting Bad Jât Tea in New Clearings.—The Finance Sub-Committee's recommendation for a grant of Rs. 760 - for this work was agreed to.

5. SENIOR SCIENTIFIC STAFF.

(a) *Director—Dr. Roland V. Norris.*—Announced that Dr. Norris proceeded on 8½ months' leave on the 8th February, and Dr. Gadd took up duties as Acting Director.

(b) *Biochemist—Dr. D. I. Evans.*—Reported that the resignation tendered by this officer dating from the 30th June, 1933, had been accepted and his application for 11 weeks' vacation leave granted. Dr Evans sailed on April 5th.

(c) *Entomologist—Mr. C. B. R. King.*—The Chairman said that this officer had been very ill for some time and two doctors had given certificates to the effect that he definitely needed a holiday in England to recuperate his health.

Three months' privilege leave was granted.

6. JUNIOR STAFF OF THE T.R.I.

Vernacular Examinations.—It was agreed that members of the Junior Staff having to qualify themselves in colloquial Tamil should be tested in Tamil by the Estate Superintendent and Visiting Agent or another planter and in Sinhalese by the Small-Holdings Officer or other Sinhalese speaking officer of the Institute or other person nominated by the Director.

7. ST. COOMBS ESTATE.

(a) *Visiting Agent's Report dated the 8th January, 1933.*—The Chairman said that a copy of this Report had been sent to each Member of the Board.

The Report was accepted without comment.

(b) *Factory Fires.*—Announced that the Commercial Union Assurance Company's letter had been referred to in *The Tea Quarterly.*

(c) *Surplus Teas.*—The Chairman referred to a letter from Mr. B. A. Campbell which had been forwarded by "London".

The Acting Director said that he thought it highly improbable that a new use for tea would be discovered because tea would not compare favourably with an animal feeding cake in food value and because tea was not palatable to most animals. He suggested that increased consumption could be obtained by propaganda rather than by research into possible new uses.

The Board approved.

8. EXPERIMENTAL SUB-COMMITTEE.

Announced that copies of the Minutes of the Meeting of the Experimental Sub-Committee held on the 14th January, and 24th February 1933, had been sent to all Members of the Board.

At the request of the Chairman, Mr. Eden briefly outlined an experiment on the handling of young tea which is to be carried out on the 1931 clearing, and reviewed the position regarding green manure plants on St. Coombs.

Mr. Tubbs spoke on the methods of layering and centring of tea bushes.

The Acting Director suggested that it would be better to revert to the practice of using the small scale machinery for manufacturing experiments and then try out good results on the factory machinery.

This was agreed to and it was decided that the Acting Director should write a short memorandum on the subject of experiments in manufacture such as he had outlined, and forward it to the Planters' Association of Ceylon, the Ceylon Estates Proprietary Association, and the Members of the Board.

9. CONFERENCE OF THE T.R.I.

Announced that the Third Conference of the Institute was held at St. Coombs Estate on the 27th and 28th January, 1933. A full report of the proceedings were published in the last number of *The Tea Quarterly*.

10. SECOND COLOMBO CONFERENCE OF TEA BUYERS, BROKERS, Etc.

Announced that a Conference of Tea Buyers, Brokers, etc., was held on the 3rd February. A copy of the summary of discussions at this Conference was sent to each member of the Board on the 6th April.

11. SMALL-HOLDERS.

Col. T. G. W. Jayewardene, V.D., was duly elected a member of the Small-holders Sub-Committee *vice* Mr. C. H. Z. Fernando resigned.

The Acting Director said that he had recently inspected the work of the Small-holdings Officer and was pleased with the results.

12. ANNUAL REPORT OF THE T.R.I.

Announced that a copy of the Secretary's portion of the Annual Report was sent to each member of the Board. The various suggestions made by members had been incorporated and a copy of the Report sent to Government.

The Meeting closed with a vote of thanks to the Chair.

A. W. L. TURNER,

Secretary.

THE USE OF NITROGENOUS MANURES IN CEYLON.

T. EDEN

The use of nitrogenous manures in tropical and sub-tropical countries is always of particular interest because they are the most expensive of all fertilizers and, soil conditions being what they are, they can be relied upon to give a steady yield response under almost all climatic conditions.

In Ceylon tea circles discussion on the use of nitrogenous manures has always provided a lively exchange of opinion. A questionnaire originally issued by *The Ceylon Observer* in 1896 and reviewed in *The Tropical Agriculturist* for that year asks, among other questions, what is the effect of the increasing use of manures (then predominantly nitrogenous) and the diversity of opinion then manifested has survived until now.

It is notoriously hard to get any relevant and reliable data on manuring from which to put into its proper perspective the history of nitrogenous manuring during the present century. The details of imports provided by H.M.Customs are almost the only source. Since almost all agricultural fertilizers are imported, these figures are especially valuable, but they necessarily relate to the whole agricultural industry of the Island. With some knowledge of the trend of production and cultural practice these figures can be made to give highly interesting details of the progress of manuring as it affects tea.

The crude returns from 1898-1924 have been gathered together, and supplemented with notes on the individual manures by Bruce in the Department of Agriculture, Bulletin No. 73 and in preparing this article this source has been used and supplemented by the more recent returns supplied by H.M. Customs. The amount of information obtainable directly from these figures is strictly limited because the varieties of manure are so many, and their analytical composition so varied. A better indication of progress in manuring can be had

by choosing a manurial constituent such as nitrogen and calculating the amount of nitrogen imported under each of the several headings relating to the nitrogenous manures. In this form all the calculated quantities are directly comparable.

For the sake of convenience the period 1898-1931 has been dealt with in triennial sections and the appended table shows the triennial totals of nitrogen in tons; the figure for 1932 has been added on the same basis, i.e., it has been multiplied threefold so as to compare efficiently with the rest of the data.

IMPORTS OF NITROGEN IN TONS.

(Triennial Totals).

	1898-1900	-1903	-1906	-1910	-1913	-1916	-1919	-1922	-1925	-1928	-1931	-1932 calculated.
Organic.												
Castor cake.	1,076	696	1,632	2,025	1,395	1,433	582	237	229	421	251	283
Ground nut cake.	—	—	309	986	2,441	5,280	4,248	2,677	3,897	6,568	5,083	3,663
Rape cake.	—	59	220	152	681	177	15	10	36	15	5	—
Fish manure	7	187	631	1,532	2,945	710	1,685	1,005	1,093	890	554	534
Fish guano.	3	—	4	10	278	307	1,339	1,564	2,490	2,155	1,437	540
Blcodmeal.	—	352	206	431	825	1,108	391	283	665	1,198	825	715
Inorganic.												
Sulphate of Ammonia.	135	199	235	505	1,200	2,116	391	480	2,517	7,078	9,033	8,055
Nitrate of Soda.	—	8	6	34	94	691	472	626	1,046	2,230	1,587	—
Nitrate of Potash.	134	109	155	231	465	527	271	807	939	1,235	966	592
Cyanamide.	—	—	—	—	—	—	—	142	331	1,612	1,515	394
Total Organic.	1,086	1,294	3,227	5,136	8,565	9,015	8,260	5,776	8,410	11,247	8,155	5,735
Total Inorganic.	269	316	396	770	1,759	3,334	1,134	2,055	4,833	12,155	13,101	9,041
Total N.	1,355	1,610	3,623	5,906	10,324	12,349	9,394	7,831	13,243	23,402	21,256	14,776
Ratio $\frac{\text{Organic}}{\text{Inorganic}}$	4·04	4·09	8·15	6·67	4·87	2·70	7·28	2·81	1·74	0·92	0·62	0·63

The first point that emerges from a study of the table is the variable fashions in the use of particular manures. In the early part of the period castor cake was the favourite fertilizer but it soon found rivals in the groundnut cake and fish manure. From 1916

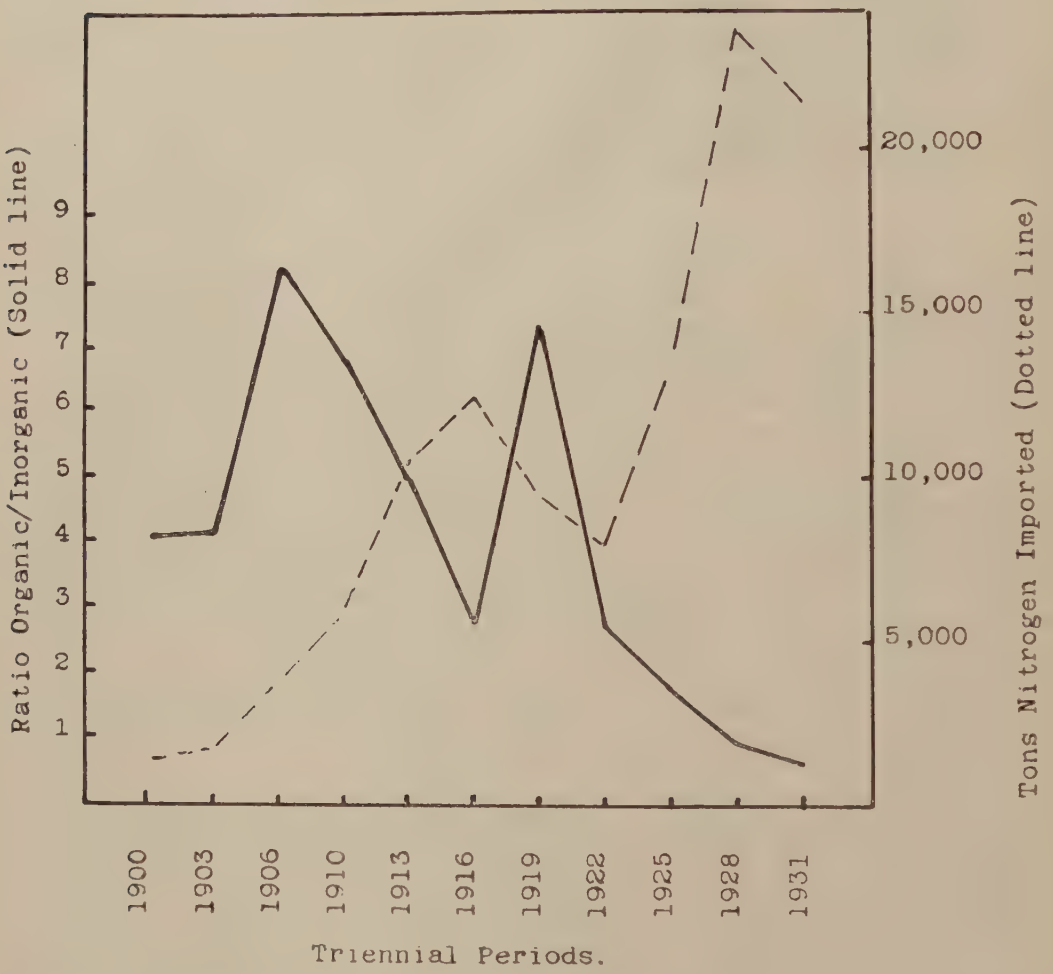
castor cake has been in decline and amongst organic artificials groundnut cake has the predominance. It is evident also that fish manure has given place to fish guano; rape cake has been virtually abandoned whilst bloodmeal provides a substantial though only moderately popular source of manurial nitrogen. These fluctuations are doubtless largely determined by corresponding changes in price per unit of nitrogen and by the ease with which supplies can be maintained.

Of the inorganic fertilizers, sulphate of ammonia stands in a class by itself. The cheapest of all sources of nitrogen, its use has progressed by leaps and bounds till now it is not only the largest individual source, but has suffered less decline than other important fertilizers and is supplying more nitrogen than all the organic sources put together. Nitrate of soda comes second, but both this fertilizer and cyanamide have entered a very chequered stage in their history.

Equally interesting are the figures for total nitrogen employed. In general they show a steady increase checked by circumstances of a non-agricultural nature. The war years and the 1920-1921 slump had an appreciable effect on imports but recovery was rapid and mounted to quite astounding figures for the period 1925-31, notwithstanding the uncertainty of the rubber situation towards the end of this period. At the time of maximum prosperity the consumption of nitrogenous fertilizers was almost double that reached in the undisturbed period immediately prior to the war.

No account of nitrogenous fertilizers would be complete without some more particular reference to the organic versus inorganic manure situation which can be conveniently studied in the ratio figures at the foot of the table. In the early days inorganic nitrogen was negligible in quantity. This was naturally so because supplies were far distant. Till after the war sulphate of ammonia was obtainable solely as a by-product of the gas works industry whilst nitrate of soda is a South American product. Oil cakes on the other hand lay near at hand in India. The sudden increase in ratio in the period ending 1906 is perhaps at first surprising. It coincides with an important increase in total consumption for which probably the late

Mr. Joseph Fraser's advocacy was largely responsible. Under conditions of sudden expansion, and supplies of inorganics being less mobile, the brunt of the demand would naturally fall on readily obtain-



able organic manures. The graph shows that from this period the increase in use of organic nitrogen has been steady except for the exceptional circumstances of the war years. This is an even more positive and striking instance of the effect of supply and demand.

Lack of tonnage cut out inorganic fertilizers imported from a distance and the highest ratio but one was attained. By the time the next triennium was complete the normal figure had been regained.

In assessing to what extent the tea industry has participated in these remarkable changes some reference to the growth and practice of other agricultural enterprise is necessary. Taking the figures up to 1917 it is fair to represent them as largely reflecting conditions of tea manuring. At that time for every acre of rubber in bearing there were two acres of tea; moreover a young industry exploiting fresh natural resources seldom if ever manures as intensively as its older counterparts. During the last two periods rubber manuring has been diminished for other recognisable reasons, so that over a large portion of the total period the conditions obtaining on tea estates have been the predominant factor. In the light of these figures it is apparent that both the highest and the lowest prices for tea that have been experienced during the last twenty years have coincided with periods when the ratio of organic to inorganic nitrogen had fallen to a value less than unity. It would appear to be premature therefore to place all the onus for the vicissitudes of the industry on soluble artificials. Time and detailed experiments will alone give the answer. Finally, unless conditions deteriorate markedly, it would appear that the present restricted use of manures is still likely to equal that of the years before the boom and with rational treatment, the fear that estates will rapidly decline, may well prove an exaggerated one.

CORRIGENDA.

Tea Quarterly Vol. VI, Page 96, line 5 for "increase" read *decrease*.

THE GROWTH OF TEA STUMPS.

F. R. TUBBS

Two methods of planting tea are now in common use in Ceylon. One entails the use of very young plants, in the form of freshly germinated seed, or of seedlings in baskets. The other involves the transplanting of seedlings that have been grown for about two years in specially prepared nurseries.

The first method avoids the check to growth which occurs when older plants are lifted from the nursery beds and transferred to their positions in the field. In areas where "white grubs" (*Anomala* sp.) are common, however, young seedlings suffer more from their depredations than do older and more woody plants. On the patna land of St. Coombs the prevalence of this pest has rendered the use of the older plants advisable and for this reason the data to be presented will only deal with the establishment and growth of two-year-old seedlings.

At the end of July 1931, an experiment to determine the effects of five planting methods was commenced. The plants used in the experiment were selected for uniformity of height in the nursery, and were then lifted with the roots as intact as possible. The experiment was designed to enable an examination to be made of the establishment and growth of (a), seedlings planted intact, as lifted from the nursery, (b), seedlings planted after all leaves and *green* stems had been removed, the roots being left untouched, (c), seedlings treated as in (b), but with lateral roots trimmed off, leaving only the taproot, (d), seedlings planted after the main stem was cut back to six inches above the collar, the roots being left untouched, and (e), seedlings planted as in (d), but with the lateral roots trimmed off.

It will be observed that the treatments form a series; the plants in the first are untouched, in the second and third the green organs which lose water easily are removed, while in the fourth and fifth the stems are cut right back. In addition treatments (b) and (d)

differ from (c) and (e) in the presence and absence of lateral roots respectively.

There are two main questions to be answered by such an experiment, firstly, do the treatments have any effect on the number of plants which survive transplanting, and, secondly, do they affect the subsequent growth after establishment has taken place ? The first question can be answered from an examination of the number of plants alive after a given period has elapsed after planting. The answer to the second can only be secured by the comparison of more extensive data.

No one criterion of the growth of an organism as a whole has ever been discovered and it is therefore necessary to examine a series of records, such as growth in height, growth in weight, growth in thickness, etc., in order to obtain a comprehensive idea of the manner in which growth is affected by a given treatment. Were it a fact that in Nature the growth of the different parts of an organism were entirely unconnected, growth problems would not have been so extensively elucidated as they have been. It has been found, however, that if, for example, a stem grows in length it also grows in thickness. As a result long stems tend to be larger in diameter at the base than short stems where growth has proceeded under natural conditions.

An examination of unplucked tea stems which had been allowed to grow freely showed that the greater the thickness of the base of the shoot, the longer the shoot, and the greater the fresh weights of stem, leaves, and stem + leaves, while the greater the fresh weight of wood the greater the fresh weight of leaves born upon it.*

It is thus permissible to make the assumption that if two sets of plants differ in the thickness of the stem, they will also differ in height and fresh weights. This assumption was not used in the

* The values of the correlation coefficients found from fifty unplucked tea stems between the following variables are shown below :—

(1).	Thickness of stem at base and length of stem	$r = +0{\cdot}738$
(2).	Thickness of stem at base and fresh weight of leaves	$r = +0{\cdot}835$
(3).	Thickness of stem at base and fresh weight of stems.	$r = +0{\cdot}905$
(4).	Thickness of stem at base and total fresh weight.	$r = +0{\cdot}918$
(5).	Fresh weight of leaves and fresh weight of stems.	$r = +0{\cdot}906$

present experiment, it being thought desirable to test it on a practical scale. It is interesting to note that confirmation is to be found in the data about to be presented.

The percentage of plants alive and showing new growth in July 1932, twelve months after planting, showed that, on the whole, establishment was good. This was due to the favourable weather experienced after planting, the number of wet days during the remainder of the year being, August, 31; September, 25; October, 16; November, 24; and December, 21. In spite of this, it was observed that the plants under treatment (a) lost their leaves steadily, until by the end of September almost all had fallen.

A statistical examination of the establishment data showed that treatments (b), (c), (d), and (e) did not differ significantly among themselves, but that all four treatments resulted in a better establishment than did treatment (a). The mean percentages were: Treatment (a), 77·7, (b) 96·5, (c) 97·7, (d) 97·6, (e) 98·3, the significant difference being 7·02. The treatment (a) differs from the other four in that leaves and *green* stems are left upon the plant. These are the portions of the aerial organs of the plant that are least efficiently protected against loss of water to the atmosphere, the stems upon which bark has been formed being protected by its impermeable nature. The poor establishment of the plants subjected to treatment (a) is in all probability due to excessive loss of water during the first two months after planting. It is interesting to note that the lateral roots, which were allowed to remain in this treatment, presumably did not provide sufficient water from the soil to recoup the plant for the losses suffered during this period.

The efficiency of the old lateral roots in transplanted seedlings can be gauged by comparing the mean establishment of treatments (b) and (d) with that of treatments (c) and (e). The two former, in which laterals were present, gave a mean percentage establishment of 97·1 compared to 98·0 given by the two latter, in which the laterals were removed. The difference is small, and cannot be considered real, showing that the presence or absence of lateral roots does not

affect establishment after transplanting. This falls into line with the data upon the effect of transplanting on the growth of twenty-eight months old seedlings [1]. It was then found that the fine lateral roots underwent morbid changes after transplanting and were replaced by new rootlets, the formation of which occurred about two-and-a-half months after planting.

Detailed measurements were made in April 1933, twenty-one months after planting, on the bushes in the plots planted according to methods (b), (c) and (e) in order to determine whether these three methods of planting affected the subsequent growth of the bushes. It was found that height of the bushes in the treatment (b) were not significantly greater than that of the bushes in (c), (Table I). The plants subjected to treatment (e) were distinctly shorter than those in the (b) and (c) plots. This to be partly attributed to the fact that new growth in this treatment is restricted to a length of six inches of stem above the soil level, whereas in the other two treatments new shoots were produced much higher up.

TABLE I.

Growth Measurements.

Treatment.	(b)	(c)	(e)	Significant difference.
(1) Mean height of plants before pruning	89·1 cm.	83·5 cm.	54·0 cm.	7·1 cm.
(2) Mean weight of prunings per plant	0·51 lb.	0·46 lb.	0·17 lb.	0·09 lb.
(3) Mean weight of leaves per plant	0·22 lb.	0·20 lb.	0·08 lb.	0·04 lb.
(4) Mean diameter of stem at ground level	1·47 cm.	1·44 cm.	1·13 cm.	0·18 cm.

At the end of April, the plants in treatment (b) were centred at three inches above the ground level, those in treatment (c) at four inches, while those in treatment (e) were pruned back to two inches above the level of the stumping cut. The fresh weight of prunings showed that more was removed from the (b) and (c) plants than from the (e) plants (Table I). This was to be expected, owing to the absence in the (e) prunings of the large portions of central stem present in the prunings from the other two series. A measure of the new growth produced since transplanting is to be found in the fresh

weight of leaves on the prunings. Since no leaves were left on any of these plants when transplanted, all the leaves found must be associated with new stem growth. The results showed that the (b) and (c) plants did not differ significantly, but that both had more leaves than the (e) plants, (Table I). The difference is far too large to be attributed to the difference in pruning levels and it is legitimate to conclude that more growth was made a result of the two former treatments than as a result of the latter treatment.

The thickness of the central stem at ground level showed similar differences, the bushes in (b) and (c) plots having significantly thicker stems than those in the (e) plots, (Table I). In general, therefore, the plants from which only the leaves and *green* wood was removed before planting made more growth than did the plants which were cut back to six inches above the collar.

In a clearing this advantage in growth is mitigated by the fact that the new shoots produced after planting by the former methods are not as suitably placed for producing a spreading frame as are those on the cut-down plants. During the next five years, however, interest will be centred on supplying rather than on new clearings. Supplies in bearing tea have very different conditions to contend with from those encountered by plants in a clearing, since in addition to the check due to transplanting the young plant experiences the retarding effect of competition from the surrounding bushes much sooner than is the case in a clearing. Above ground the neighbouring bushes reduce the amount of light falling on the leaves of the supply, while below ground their roots branch out into the well cultivated soil filling the hole in which the supply has been planted. In addition, coolies pass through a field of bearing tea far more frequently than through a clearing, thereby increasing the liability of the young plant to suffer damage. It is therefore desirable that the young shoots upon the supply should be produced as high above the ground as possible, they being thereby less liable to accidental damage and in a better position to compete with the established bushes for light. This is rendered impossible when supplies are stumped to four or six

inches above the collar, the production of new shoots being thereby confined to the stem near the ground level. When only the leaves and green wood are removed, however, the plant is in a position to produce shoots two or more feet above the soil. If the field is supplied early in the pruning cycle, supplies of this type will establish themselves and grow freely during the remainder of the cycle. They may then be centred about a little before the field is pruned in order to give them a start before the established bushes. It is not advisable to centre sufficiently early for many new shoots to be produced before the rest of the field is pruned, since damage to them would inevitably result.

The data discussed have been obtained at St. Coombs, and experience alone will show whether the same results may be expected in different districts under varying conditions of soil and climate. They are, however, sufficiently conclusive to indicate that the use of plants from which the leaves and green stems alone have been removed may well prove advantageous when supplying vacancies in bearing tea fields.

REFERENCE.

Tubbs, F. R.—Tea Research Institute Bulletin No. 5, 1930, p. 22.

ON THE THEORY OF WATER EVAPORATION AND ITS APPLICATION TO WITHERING AND DRYING OF TEA.—Part II

SVEN STRÖMGREN.

In view of the foregoing,* the problem of control of drying should not be very difficult to solve, and without touching all possibilities I will directly describe the method which I consider most rational.

Primarily, the controls should be completely automatic. Nobody in a tea factory will take the trouble to look after conditions in the dryer continuously. It must therefore be possible to run the dryer without any supervision whatever, the only human element being the man who carries the leaf to the dryer; and even he could be done away with by installing a conveyor. Then the tea could be fed into the dryer continuously, or intermittingly as necessitated by the organisation of the factory, and the dryer would not only adjust itself to the wetness of the leaf, but also turn out tea with a practically constant moisture content; it would stop when no leaf is fed in and start again immediately leaf is supplied. Without going into details as to how this is achieved I would state that it can be done for any type of dryer, but that electrical drying lends itself more freely to this type of control.

In an automatically controlled dryer there would be three points of control; the first point to control the conditions of the air entering the air heater, the second to control the condition of the air between the air heater and the dryer proper, and the third one to control the condition of the exit air. The first point of control is not always necessary, and I shall omit it from this consideration. The second point of control is used to control the temperature or the drying potential of the air that enters the drying chamber proper; control of drying potential is, however, more complicated than control of

* See Part I in *Tea Quarterly* VI, pp. 67-77.

temperature. The third control is made to control the exit temperature or its drying potential. When one of the points controls the temperature, the other should control the drying potential.

It has been suggested that the third point of control should be placed under the first or second tray from the top instead of at the exit. The air that passes the former point however is not able to tell the full story of the drying process, and such a control will be less accurate than one in the exit. The reasons put forward for placing the control underneath the trays are that the leaf at this point has been heated up by the air, and that the drying process is not fully under way up to this point. The heating up of the leaf only absorbs from 1 to 2 per cent. of the total heat used in the drying and is of no importance, since that loss has hardly any influence upon the condition of the air whatever. Furthermore, it is very simple to prove that more water is evaporated from the two top trays than from any other tray in the dryer. Another reason urged for putting the control below the trays is that a control there would prevent stewing. It is obvious from what has been stated earlier that no temperature in itself can prevent stewing. However, with the double control as outlined above, the temperature of the air at any point inside the dryer can be easily maintained at a definite level should it be desirable to do so.

The temperature of the air entering the drying chamber can be controlled (second control point) by a device which will vary the number of B.T.U's that enter the drying chamber proper with the air, or better still, by one which will vary the amount of heat dissipated into the air in the air heater, i.e., one which controls the amount of fuel or electricity consumed. When the dryer is empty, this control would close down the air heater, and give only sufficient heat to keep the dryer warm until new leaf is put in.

The third control would be effected by a device to vary the amount of air or the amount of leaf that passes through the dryer, or to vary the composition or the elastic force of vapour of the air that enters the dryer chamber proper.

These two controls, i.e. the second and third, would co-operate; the third control would immediately signal to the second control when the top tray became empty or when dry leaf entered the dryer. The third control would then, for instance, shut off a certain amount of the air, and the second control would in consequence decrease the heat dissipated into that air, always keeping its temperature constant at the point of entry into the drying chamber proper.

I have dealt within the problem of control without going into mechanical details. I do not believe that a great improvement in the present control can be achieved without converting the dryers into fully automatic machines.

THE PHYSICAL WITHER OF TEA.

Although the wither takes place at a considerably lower temperature than the drying, there is in principle very little difference between the two processes, the main difference being that the leaf during withering is nearly in equilibrium with the air surrounding it throughout the whole process.

So long as the leaf carries surface moisture from dew or rain it is theoretically and practically a "wet" substance, and it acquires the temperature of the wet bulb thermometer. From the moment the surface of the leaf is dried and until the leaf reaches a certain degree of dryness, the evaporation of moisture will still proceed comparatively freely and the leaf may still be considered as physically "wet". Even during this latter period, it will keep a temperature practically equal to the wet bulb if the lofts and the fan capacities are suitably designed. During the third period, the leaf departs from this rule, and a certain resistance is created inside the leaf against evaporation, and its temperature increases above the wet bulb.

It has been pointed out previously that the evaporation of water into air is proportional to the drying potential. As the air proceeds through the lofts, its drying potential decreases, and consequently, if all other factors are constant, the rate of evaporation of water also decreases until the air finally becomes saturated, when no water will

evaporate at all. When this occurs, if the leaf is still a "wet" body, the elastic force of vapour in the leaf and in the air will be approximately equal. However, the evaporation may also cease, because the elastic force of vapour in the leaf continuously decreases owing to increased dryness and so becomes equal to the elastic force of vapour in the air. This is what may happen during the later period of the wither; the evaporation from the leaf may cease although the surrounding atmosphere is not saturated and the wet and dry bulb thermometers show a temperature difference. In this phenomenon lies a solution to the problem of producing withered leaf with an even and constant moisture content.

I have shown previously that evaporation will cease when the elastic force of vapour in the leaf equals that in the air. If, therefore, during the latter part of the withering one could keep an elastic force in the incoming air exactly equal to that which exists in ideally withered leaf, one could blow that air continuously over that leaf without the leaf becoming any dryer. At present the withering process is mostly carried out with no automatic control, and a comparatively dry air, i.e. air with a high drying potential is used. When such air passes over leaf for a considerable time, the final dryness of the leaf may become 30 per cent. or less. If on the contrary, one utilised air with a low drying potential and with a certain elastic force of vapour, one could cause the wither to cease automatically at a certain dryness of the withered leaf.

The drying potential has also to be considered in conjunction with the time allowed for the wither; and when the rate and degree of wither are properly combined, the withering process would be fully rationalised.

A low drying potential affords another advantage in withering. It is known that different parts of the flush evaporate water more or less freely, mainly depending upon the surface exposed to the air by various parts. During a fierce drying action, the parts of the flush with big surfaces exposed will evaporate water more quickly and

become drier than other parts. This must by all means be avoided, but it can only be done by arranging for a comparatively low rate of evaporation throughout the whole withering.

Another problem is the evenness of the wither in different parts of the loft. With a high drying potential in the air, the leaf nearest the air inlet will reach a very high degree of dryness while the leaf at the end of the loft or in the middle, if any reversible system is used, will become less dry. Even with a comparatively wet air in the loft, it is true that at the beginning of the wither there will still be a difference between the leaf near the entrance and the leaf at the exit, but this difference will disappear almost entirely, because when the leaf nearest the entrance has reached a certain dryness, this leaf will not evaporate any more water to speak of and the air will pass practically unaffected over it, ready to act upon a leaf with a higher degree of wetness. This evening out will not occur during the two first periods of the wither, but takes place during the last period when the leaf has become slightly hygroscopic.

Planters are always of the opinion that the natural wither is preferable to any artificial. In my opinion, this is solely due to two defects in artificial systems. The volume of air actually passing through the lofts is often too small, and the drying potential which, in consequence, has to be employed is far too big. There is no difficulty either in theory or practice in reproducing the conditions of the atmosphere which are known to produce a good natural wither, every day of the year. Furthermore, one can control the condition of the air in such a way that it suits leaves of various moisture content and so improve upon average natural conditions.

It is generally believed that a wither should take place at a low temperature, which does not necessarily mean a low dry bulb temperature, but a low wet bulb temperature. However, the difference between the two should be comparatively small. A good artificial withering system ought to provide for a low temperature of the leaf itself. The only cheap method of achieving this is to cool the air by humidification, and this is only possible when the air is dry. The

maximum number of degrees which the air can be cooled in this way is the hygrometric difference. If for instance, the air has a hygrometric difference of 15°F. one may cool such air by humidification 10°F. and it will still have a hygrometric difference of 5°F. which is quite sufficient to complete any wither if only the amount of air passing through the loft is sufficient. This method of cooling can be utilised only during spells of dry weather. If one wants to cool the air also during wet periods, one has to use some kind of refrigeration. In Assam where the air occasionally reaches 100°F. and is almost saturated, one would like to cool such air to say 80°F. and still have a hygrometric difference of 5°F. To achieve such cooling however was a very expensive process so long as refrigerating machinery had to be used. Fortunately, nowadays one knows of processes for cooling air where no machinery is required and in which, peculiarly, heat is the only agent employed.

To sum up, the wither can be fully controlled by controlling the drying potential in such parts of a country where excessive temperatures do not occur. It is, however, not sufficient to keep the drying potential at a constant value during the whole time of the withering. On the contrary, it is necessary to vary the potential according to the requirements of the leaf, especially towards the end of the withering and then to use air with a potential which will give and maintain the final moisture content in the leaf desired. A controlled wither of this type consists of two different periods, a first period, during which the surface moisture of the leaf is taken off, when a comparatively high rate of evaporation is maintained, and a second period, the main purpose of which is to even out the wither throughout the loft and to reach the final constant moisture content.

The practical method by which this can be achieved is an automatic control of the drying potential of the air with a super-imposed time control, which control is actuated by the original wetness of the leaf that enters the withering loft. In order to show the accuracy with which the final moisture content of the leaf may be reached with this method, the following experiment has been carried out.

Leaves of originally different moisture content, viz. 80 per cent. and 76 per cent. respectively were placed beside each other on the same tat and withered during 24 hours with a fairly strong breeze of air passing over it with a controlled drying potential. The result after 24 hours was 60·0 and 60·7 per cent in the two different types of leaf. This example is not intended to show that this accuracy can be reached in a big loft; even if the leaf in the experiment had finished off with 61 and 59 per cent. the result would have been considered as satisfactory.

If a good artificial wither is to be attained, it is essential that a great amount of air is used. Unfortunately many firms selling fans, when stating their capacity give a capacity corresponding to free inlet and outlet, which capacity is of no interest to the man who is going to instal the fan in a factory where it is not going to have free inlet and outlet. In lofts there always exist a certain resistance against air movements, and the bigger this resistance, the smaller the volume a certain size of fan can push through. It is therefore essential when installing an artificial withering system to know what resistance in the lofts one has to deal with, and the fan capacity must be chosen accordingly. In this connection it may interest the reader to know that the decrease in air volume from a propeller fan by resistance is considerably more than the decrease when using an enclosed fan. The propeller fans common in tea factories at present are not capable of dealing with a higher pressure than $\frac{1}{4}$ in. water column without losing a considerable amount of their capacity. For artificial withering systems one therefore ought to use either enclosed fans or propeller fans of the high pressure type which at present can be made to deal with pressure up to 8 inches.

The path along which the air travels in a loft is also of importance and the shorter distance the air travels the more even will the wither be. If therefore the air was blown across the loft instead of along it, and in addition was reversed, a higher degree of evenness would result than normally occurs with any natural wither.

With these remarks on withering I will conclude this article and I only hope that it will be of some use to the tea industry. I have as much as possible omitted to deal with the matter in a purely theoretical way, and I have always tried to exemplify each theoretical statement with practical experience common to every planter.

SOIL EROSION.—II.

T. EDEN.

LOSS OF FERTILITY.

Loss in fertility of a soil on account of erosion may be due to a number of causes. In the majority of cases the first effect to be felt is a deterioration of tilth. In tropical soils that are hand-cultivated the production of a good tilth is not so noticeable as during the preparation of a seed bed by mechanical cultivation. Nevertheless a good tilth can be judged by the relative freedom of a soil from caking and cracking, and steps can be taken to restore a measure of friability to a heavy soil and body to a light one by suitable cultivation operations, no matter how laborious this may prove.

The loss of nutrients in the soil and in the run-off water that carries it along is not, like loss of tilth, an easily noticeable wastage except in the light of diminishing crop returns, but it can reach alarming dimensions. The magnitude of the losses due to soil erosion have been measured in America by means of both chemical analyses and crop studies; the one method supplements the other.

Analysis provides a fairly rapid method of assessing the possibility of important fertility losses but it is by no means infallible. Most soils change their composition as the depth increases so that, as erosion proceeds, the gradient, or profile as it is called, of nutrient concentration alters in a corresponding manner. Some soils however are very uniform in profile and very deep so that even though quantities of soil are being washed away, the profile changes not at all, and analysis may fail to show how great is the damage suffered. On the

whole if the soil is examined *in situ* the gradient or profile for nitrogen is the safest indication as well as being generally the most important.

In a few experiments it has been found possible to collect and analyse the eroded soil. One of the most complete experiments is that at the Missouri Experiment Station which answers very fully the question as to how much, and in what form, loss of nitrogen occurs.

Both the eroded soil and the run-off water were collected and analysed so as to give in pounds per acre the readily soluble inorganic nitrogen content and the corresponding amount for the less soluble organic form.

Annual Losses of Nitrogen in Soil and Run-off Water.

Pounds per Acre.

		Nitrogen in Soil.		Nitrogen in Run-off.	
Plot.	Soil	Insoluble.	Soluble.	Insoluble.	Soluble.
A	8900	92·39	3·01	2·00	0·229
B	9400	71·42	2·45	2·07	0·219

It is at once apparent how much nitrogen is removed in the eroded soil. Each year more than enough to raise a good crop of any farm produce is lost, most of it in an insoluble form. The soluble nitrogen is low, but that might be expected after the thorough leaching to which the eroded soil is subjected. The run-off water on the other hand contains relatively little nitrogen, and the very low concentration of soluble nitrogen is remarkable. What happens to the soluble nitrogen that is undoubtedly present in the surface soil where bacterial activity and nitrification are most pronounced; a good arable soil may contain as much as fifty per cent. of its nitrogen in soluble form ? The explanation probably lies in the fact that the first portions of rain drive the soil moisture containing soluble nitrogen into the deeper layers of the soil so that although this particular type of nitrogen may be lost eventually in seepage, it is not markedly depleted as a direct result of erosion.

In so far as these well authenticated results are of general application they suggest that in climates involving heavy rainfalls organic nitrogen is at least as easily lost through erosional agencies as its more soluble counterpart. Nitrogen losses can therefore only be prevented by minimising soil losses.

Turning from analyses to crop studies, the evidence for the serious consequences of erosion is just as striking. Mosier and Gustafson took an eroded site and attempted to grow crops in pot culture on soil derived from the most severely eroded parts of the site. The results were poor in the extreme. By adding the common soil nutrients they greatly improved the production and thus demonstrated that nutrient deficiency was the main cause of poor growth.

Percentage Yields for Manured and Unmanured Eroded Soil.

	Unmanured.	Phosphate Potash & Lime.	Nitrogen & Lime.	Nitrogen Phosphate & Lime.
Wheat.				
9-year averages.	100	115	460	550
Oats.				
5-year averages.	100	111	330	440

Phosphate and potash without nitrogen produced only small increments; nitrogen gave the most striking result, and nitrogen and phosphate in combination proved to be the chief requirements. In addition to the cropping studies the same workers analysed the soils taken from the site. The undulating land on the area was rather richer in nutrients than the steeper hilly land. The comparative richness of the soil washed down to the bottom of the area sufficiently indicates how the higher areas were depleted. The pot culture experiments were carried out on the soil from hilly land.

Composition of Eroded Sites and Eroded Soil.

	Organic matter Tons per acre.	Nitrogen lbs. per acre.	Phosphorus lbs. per acre.
Undulating land	23·1	2330	819
Hilly land	17·1	1805	746
Bottom land	45·3	4693	1403

It may seem on casual inspection that even on the eroded portions substantial reserves were left, but the cropping figures undoubtedly give the surer indication of the real value of eroded soil.

Manuring operations in estate and farm agriculture should aim at keeping the potential nutrient wealth of the soil at least constant if not actually increasing. Figures such as the American soil work provides, show most clearly how unnecessarily expensive that policy must become unless the root problem of erosion is tackled first of all.

A PLANTER'S SOLILOQUY*.

(With Apologies to "Hamlet").

To weed or not to weed; that is the question.
Whether it is better on the estate to suffer
The hated presence of a cover crop,
Or to take measures 'gainst this noxious growth
And, by uprooting, kill it. To weed; to scrape;
No more; and by this means to say we 'scape
The gibes which pioneers are wont to get
From fellow planters; 'tis a consummation
Devoutly to be wished. To weed; to scrape;
To scrape; perchance to erode; ay, there's the rub;
For in that scraping clean what soil may go
While we are wielding karandi or spear
Must give us pause; there's the restraint
That causes thinking men to hesitate.
For who would bear the V.A.'s contumely,
The neighbour's scorn, the thought of lost manure,
The fear of root disease, of falling yield,
Of yellowing of foliage, and the taunt
That cover crops are ultra-modern things
And violate traditions of the past,
When he himself might all his critics please
By following custom ? Who would trials make,
Preferring to retain what soil he has
Than work with other that he knows not of
But that the promptings of sound common-sense,
The scientific method and the laws
Which Mother Nature teaches, goad him on
And make him rather brave his fellows' scorn
By treading in the path of pioneers
Than rest content with what his forebears did
And pass his life in ease and quietness,
What time his soil goes down into the stream
And more must be created from hard rock.
Thus conscience does make heroes of the few,
And thus the path of progress is marked out
By those who from tradition free their minds
And hasten on the road of new ideas,
While laggards follow.

* Reprinted with permission of the *Times of Ceylon.*

GROUND COVER CROPS.

H. C. COSENS

[The following notes have been received from Mr. H. C. Cosens of Strathspey Group, Maskeliya, and are published here because of their general interest. We hope that these notes are but the forerunners of many others from different sources.—Ed.]

MUSTARD WEED *(Cardamine hirsuta).*

I have come to the firm conclusion, after a good many years' observation that mustard weed is one of the most friendly growths

MUSTARD WEED
(Cardamine hirsuta).

CHRYSANTHEMUM WEED*
(Artemisia vulgaris).

we can have under our tea, if properly handled. My experience is that it has a life-cycle of about 2½ months under most weather conditions. It springs up, particularly in forked areas, in a thick carpet and seeds in less than one month, thus defeating the efficacy of the usual monthly round. In any case, to scrape it thoroughly causes

*From a painting in the Peradeniya Herbarium, kindly loaned by the Director of Agriculture.

such a soil disturbance that it, and all sorts of weeds, spring up in redoubled quantities and how much soil is lost through erosion it is impossible to estimate. Hand weeding is out of the question on account of cost. Whilst growing to its maximum height of about 4 inches it forms a perfect cover to the ground and breaks the force of the rains. Other types of weed have to be picked out from amongst it and for the first round this may be a little bit tricky, requiring careful supervision. After seeding, the mustard weed gradually turns a straw colour and later drops its leaves. The stalks continue to stand, slowly turning black, and eventually collapse as almost invisible black threads on the ground at about $2\frac{1}{2}$ to 3 months from germination, leaving a clean weeded appearance. A second very thick crop soon appears, probably rather less luxuriant than the first and at the same time other weeds are definitely less noticeable. Each successive crop is likewise less vigorous, and weeds, generally, give less and less trouble, and drains receive less and less silt. A forking is liable to revive the growth of mustard—all to the good, I would hazard. I have tried out this routine over several selected areas and in one small area for over three years. It used to be a very weedy field and is now most popular with the contractors. The tea has certainly not suffered. Care is necessary during the first cycle of the mustard weed not to let grass in.

CHRYSANTHEMUM WEED *(Artemisia vulgaris).*

I have this plant firmly established over a 15-acre field and believe it has been in a similar condition for many years. The cost of its removal by the root is almost prohibitive and the operation entails much hand forking and grubbing to a considerable depth. Beyond periodically forking round the periphery of the affected area to prevent spreading, and the carrying of all growth removed to the next road *above* for destruction, I have not touched the "weed" for several years. Within is a thick mass. The tea appears hardy and the drains are free from silt. Chrysanthemum roots are woody and appear to be hungry feeders but the fact that the heads grow to a maximum height of 4 inches to 5 inches* would seem almost to belie this supposition. It is hard to believe that this fearsome looking growth can be beneficial, but are we right in regarding all foreign

* The plant frequently grows to a height of 2 or 3 feet when not subjected to damage by pluckers, etc.—Ed.

growths as injurious without proof to that effect ? To adopt the British judicial attitude and regard each growth as innocent until proved guilty would, surely, be fruitful of the much quicker results merited by the seriousness of the soil erosion problem.

A NOTE ON THE VARIABILITY OF TEA SEEDLINGS.

F. R. TUBBS.

A careful comparison of a series of tea seedlings will show that considerable variation between plant and plant is observable in such characters as height, leaf number, leaf shape, and amount of branching. These differences are most obvious among seedlings from unselected seed-bearers, but even where the seed-bearers have been carefully selected for uniformity, it is still observable in less degree. It may be thought that the differences in the latter case are due to differences in the seed-bearers that have escaped the eye of the selector, but complete uniformity will not be found even among the progeny of a single seed-bearer. The causes of variation fall into two categories, firstly, differences in the local environmental of individual seedlings and, secondly, differences in their inherited constitution.

The form of a seedling is influenced by its environment, the fertility of the soil and the amount of light, for example, having considerable influence. The amount of water and of light available to a seedling varies considerably from place to place in a seed-bed, and in consequence variations in the form of the seedlings result. The inherited constitution is also by no means the same in each seedling, and therefore, just as children of the same parents often differ considerably in form, large variations occur among them.

It would be possible to reduce the differences in inherited constitution considerably by always self-fertilizing the flowers of a number of generations of seed-bearers. But the work would have to be continued for many decades before the plants would be uniform.

It is possible, however, to compare the relative importance of environmental differences and of inherited differences as causes of variability. In a previous note on the vegetative propagation of tea [1], it has been pointed out that two plants can be obtained from one seed by allowing it to germinate, and splitting it down the axis of stem and root in such a way that each half bears one seed leaf. The latter contains sufficient reserves to enable the halves to heal their wounds and to grow into normal plants. It is possible to sub-divide further and experiments are in progress to determine the feasibility of obtaining four plants from one seed. To date, considerable success has attended the production of identical twins.

The differences between the twins will be due to variations in the local environment of the plant, since they have the same inherited constitution. The differences between pairs of twins will be due both to differences in environment and to differences in constitution, since they are produced from different seeds. The difference between the variation within pairs and the variation between pairs will indicate the importance of the differences in inherited constitution, since if the latter are unimportant the variation will be the same. If they are important, the variation between pairs will be larger than that within pairs.

Seed was obtained from good jât bearers known to be relatively even in type. From these seeds a large number of pairs of twins were obtained, which, after growth in washed sand, were transferred to baskets. Six months after the "twinning" operation the height and number of leaves were measured on one hundred and eighty-seven pairs. The height was taken from the junction of the base of the seed leaf with the stem to the base of the apical bud, plants from which the cotyledon had already dropped being omitted. In counting the leaves, fish leaves were not included.

The following figures are an index of the variability between and within pairs:—

	Height.	Leaf Number.
Between pairs	1·918	4·687
Within pairs	0·743	2·251

Statistical test shows that these differences are real, and are not due to chance. Thus the variation between pairs is larger than that within pairs. It may therefore be concluded that differences in inherited constitution do play an important part in producing variations in tea seedlings.

It is a long-established custom to remove for planting purposes only the strongest plants from tea seed beds. The weaker plants that remain are either pulled up, or else allowed to grow until they attain a suitable size for planting. The foregoing data show that a large proportion of the small plants will have failed to attain a useful size owing to an inherited tendency to grow weakly. The fact that the removal of competition from the more vigorous plants around them enables them to attain a useful size does not remove this fundamental objection to their use. It is therefore better to discard all the weaker plants entirely.

The facts described above also indicate a possible method of improvement in the technique of tea experimentation. The first requisite for accurate experimental work is uniformity of the tea bushes. The data show that additional uniformity may be obtained by the use of vegetatively propagated material, and the use of twin plants is therefore being adopted in small scale experiments involving the comparison of two treatments.

REFERENCE.

(1) Tubbs, F. R.—A note on the vegetative propagation of tea.—*Tea Quarterly*, 1932, **5**, 154-156.

A SULPHUR DEFICIENCY DISEASE OF THE TEA BUSH.

(REVIEW)

In recent years an obscure disease of the tea bush, to which the name Yellows has been applied, has seriously handicapped the production of tea in Nyasaland. In 1927, it was characterised by Dr. E. J. Butler as "unquestionably one of the most serious diseases to which the tea bush is liable." In a recent publication* Dr. H. H. Storey, of the East African Agricultural Research Station, Amani, and Mr. R. Leach, of the Department of Agriculture, Nyasaland Protectorate, have presented evidence that this disease is the result of a deficit of sulphur in the bush, relative to other necessary elements, and that the disease can be prevented and usually can be cured by supplying sulphur in an available form to the bush.

The affected tea bush passes through a characteristic degeneration ending in the death of individual shoots and branches, and finally of the whole bush. In the early stage there is little or no reduction in size of the leaves or in length of the internodes, but the leaves become mottled with yellow, the network of veins remaining green. As the disease advances, the reduction in the size of the leaves and in the length of the internodes becomes marked. The mottling of the leaves gives way to a general severe chlorosis. The leaves tend to be somewhat uprolled and have a peculiar stiff texture, which causes them often to break when bent. Frequently the leaf tissue dies from the tip or edge, shrivelling to a dark brown colour. With the further development of the disease these changes become more pronounced. The reduction of the leaf size may be extreme, mature leaves sometimes being no longer than 1·5 cm., while the shoot is thin and weak with closely crowded nodes. Meanwhile all leaves formed after the disease appeared, except the youngest, are shed. Lateral buds make premature development, producing stunted shoots with minute yellow leaves. Eventually the terminal bud of the shoot dies and a gradual dieback of the shoot sets in. The final state is a leafless bush bearing many dead or dying thin shoots, although occasionally living axillary shoots may be found near the base.

* The Annals of Applied Biology, Vol. XX, pp. 23-56. (February, 1933).

The disease rarely progresses uniformly in the several branches of a bush. Usually some branches are severely diseased while others are mildly affected or even healthy. Occasionally an extremely unilateral effect may be seen where one half of a bush is severely diseased and the other half healthy.

Tea bushes affected with yellows disease occur in almost all the gardens of Mlanje and Cholo areas of Nyasaland. Their frequency varies greatly between different gardens, but in the majority this disease is an important factor in limiting production.

In certain soils, (dark grey to dark brown friable soils) formed under the highest rainfall, yellows disease is liable to appear early in new plantings on virgin soil. In others, (red soils of Mlanje and Cholo), yellows only follows a loss of fertility through cropping, erosion or some other cause.

The spontaneous appearance of yellows in young plantings of tea in certain newly-cleared soils indicates that the conditions that produce yellows are already present before agricultural operations are undertaken. Planters' experience shows that those bushes that survive the initial distase phase generally make good growth subsequently. The importance of the disease during early growth may be judged from a count made in a typical garden; at the end of the first year's growth the incidence of the disease averaged 36 per cent. In a similar garden where the young tea at the time of planting on virgin soil received a dressing of a fertiliser containing a sulphate, the bushes were free from yellows disease.

On the red soils, yellows disease is usually unimportant until a deterioration of the soil has occurred subsequent to the initial clearing from bush. The deteriorating influences appear to have been primarily erosion, prolonged cropping and competition. Thus the disease is prevalent on badly surface-washed slopes, on the sides of drains and roads, on lands that have previously borne other crops than tea and particularly on the sites of native gardens, along forest margins, often around the bases of large shade trees (usually *Albizzia* spp.) in old established gardens, and in neglected gardens where weed growth has remained insufficiently checked. On the other hand the disease is least in evidence in valleys that have received the soil

washed from the hillsides and in newly-cleared land protected from severe surface erosion. Bushes growing on anthills rarely develop yellows, although often growing poorly and suffering from drought.

Yellows is often very severe in certain small swampy areas, where water rises to the surface during the rains. Drains cut in these areas carry away a large volume of water. It is uncertain whether the disease is here to be attributed to the leaching of the soil by this flow of water or to the reducing conditions produced by water-logging.

There is a seasonal rise and fall in the incidence of the disease. It is worst in November, at the end of the dry season; thereafter there is usually a gradual improvement up to the end of the rains. This change is most marked in the swampy areas mentioned in the last paragraph.

All of the several types of plants grown from the local seed which form the bulk of the Nyasaland tea, are subject to yellows disease. On the whole, however, they appear to suffer less than plants raised from seed recently imported from Assam and Ceylon. Plants of all ages may suffer; young seedlings in the nursery, young and old transplants, and young and old plants which have grown undisturbed from seed at stake.

FIELD EXPERIMENTS.

The difficulties in field experimentation with tea yellows are numerous and include problems not normally encountered by the field experimentalist. The observed seasonal rise and fall in the incidence of disease has already been mentioned; this was overcome to a large extent by making the final records at the end of one or two full years from the start of each experiment. Where this precaution was not observed it was necessary to differentiate between the natural change in the healthiness of experimental bushes and that due to treatment.

Field experiments were used to attack the problem from two angles: (1) the cure of the bushes already diseased, and (2) the protection of new plantings from the disease. For experiments in the former, recourse was made to old established gardens. Such

gardens consisted of (a) healthy bushes, (b) bushes in all stages of the disease, and (c) many blank spaces where bushes had died out from the disease. The distribution of the several categories was never approximately uniform over any considerable area. Consequently these areas afforded highly unsatisfactory material for the lay-out of plot experiments. When experiments were performed upon new plantings, it was necessary to choose a site for the experiment where the disease might be expected to appear naturally in untreated plants. The dark soils satisfied this condition; but elsewhere suitable areas could be obtained only by clearing land which had borne old diseased tea. But such land had in part laid fallow (where bushes had died out in the past) while other parts had recently borne either healthy or diseased bushes. Such areas were therefore the opposite of uniform in respect of the factor that produces yellows disease.

This lack of uniformity of the areas under experiment was overcome satisfactorily by using the single bush as the unit and by using an ingenious method of measuring the degree of healthiness of the bushes which allowed a statistical examination of the results.

The preliminary experiments, which are described in detail, demonstrated that tea yellows is a disease which may be largely cured or prevented by treatment with certain fertilisers. The variety of treatments employed allowed of no certain conclusion as to the particular material responsible for the effect. In every instance, however, where improvement was noted the treatment included either ammonium or potassium sulphate.

The results of further experiments pointed consistently to sulphur as the element concerned in the amelioration of the yellows condition in tea. In all instances an improvement, generally statistically significant, followed the application of a sulphur containing material to the soil. On the other hand, treatment with a wide variety of other materials, containing little or no sulphur, produced no effect on the disease or gave indications of increasing it. The only apparent exception was the response to potassium chloride in one experiment, and here the small admixture of potassium sulphate, found to be present in the sample used, makes doubtful the interpretation of this result.

The improvement obtained by sulphur treatment of diseased bushes sometimes amounted to complete cure. More often however the data show a significant improvement not amounting to a complete cure. As the results are expressed in terms of the mean it is evident that the maximum possible improvement can be achieved only when every treated bush makes a complete recovery. A large number of the treated bushes recovered completely and the improvement in others indicated that in time they would be completely healthy. In one experiment in which 4 years elapsed after the first treatment, the treated bushes were for practical purposes, entirely healthy.

For the most part the experiments were performed on bushes in only a moderately advanced stage of the disease. It was considered that in the later stages of the disease secondary influences might prevent a recovery even when the primary cause of the disease was removed. Nevertheless, treatment with sulphates frequently proved successful in bringing back to health bushes that appeared to be on the point of death.

These experiments in the treatment of the soil with fertilisers leave in doubt the part played by sulphur. Either the sulphur enters directly into the nutrition of the tea bush, or it exerts some indirect chemical or biological effect upon the soil which results in a visible improvement in the health of the bush. In order to elucidate this point, endeavours were made to reproduce the symptoms of yellows disease in solutions of known composition.

WATER CULTURE EXPERIMENTS.

The series of plants which received all nutrients except sulphur rapidly developed symptoms typical of yellows disease. At the end of 2 months one plant had produced mottled leaves, with the lamina pale and the veins dark, and later it produced only minute yellow uprolled leaves, which were quickly shed. The remaining three plants did not show the mottled phase, but passed at once to the production of small uprolled yellow leaves, which scorched on the margins and soon fell. Meanwhile in all these plants the growth of the stem was much reduced, all internodes being very short. After 14 weeks, one plant, which had previously reached the chlorotic small leaf condition, received potassium sulphate at the rate of 0·25 gm.

per litre. The one unshed yellow leaf, which was at this time half-scorched, became green in 10 days and later the shoot grew out into healthy green leaves of normal texture, but somewhat undersized.

The plants in the remaining series showed various abnormalities of growth, but none resembled yellows disease. Those lacking nitrogen bore pale green leaves, but of normal size and texture, and growth soon ceased. The leaves of the plants lacking potassium, phosphorus, chlorine and magnesium were normal in colour and texture, but (except in the phosphorus series) scorching was more severe than in the full nutrient series and in all the growth was inferior. The plants lacking magnesium shed all leaves rapidly, thus superficially resembling those affected with yellows disease; but at no stage did they produce the uprolled yellow leaves typical of this disease.

In another experiment the seedlings were set in a solution lacking sulphur (but otherwise containing all necessary nutrient materials) to which had been added sodium sulphate at the rate of 0, 0·00027, 0·0027, 0·027 and 0·27 gm. per litre. Typical yellows symptoms appeared in all plants receiving no sulphate and in those receiving 0·00027 and 0·0027 gm. of the sulphate per litre. The symptoms were developed only mildly in the last. The plants that received 0·027 and 0·27 gm. of the sulphate per litre made healthy growth.

Experiments were also carried out upon bushes in the field to determine the influence on yellows disease of different salts when introduced into individual branches, which throughout the experiment remained attached to the parent bush. These experiments showed that the leaves borne by branches to which sulphate solutions had been introduced rapidly developed a normal green colour whereas the introduction of salts other than sulphates had no effect on the disease.

From these and other experiments it is evident that yellows disease is the result of a deficit of sulphur in the plant, relative to other inorganic constituents. This qualification is made because it appeared from certain experiments that the characteristic symptoms are not produced under conditions of general shortage of all nutrients.

The need of plants in general for sulphur for their normal metabolism has long been known, and increases in yield have been obtained with several crops from sulphur dressings. The authors however believe that their studies of tea yellows provides the first instance where a specific disease of a crop plant, with characteristic symptoms, has been shown to be due to sulphur starvation.

C. H. G.

SMALL-HOLDINGS.

C. H. GADD.

The Small-Holdings Officer was appointed in October, 1932 and after a course of training at St. Coombs he was stationed near Gampola with instructions to carry on intensive work in that area.

The work in any village or group of villages is normally started by arranging a meeting of small-holders at a convenient time and place. The Minor Headmen have given valuable assistance in arranging these meetings which are normally well attended. This procedure enables the Small-Holdings Officer to meet the small-holders, to explain the objects of the work, to discuss such questions as Green Manuring, Draining, Pruning and Plucking and to arrange a convenient date to visit their holdings. The holdings are visited and demonstrations given of the various operations of tea cultivation. Suggestions are made for the improvement of holdings and specific advice is given on particular problems.

As a result of this preliminary work a number of small-holders usually volunteer to work their holdings according to the Officer's instructions. It is not to be expected that all such volunteers will carry through their undertakings, but it is hoped that many of their holdings will in time become model plots and permanent demonstrations to the surrounding cultivators.

Up to the present, work has been concentrated mainly in the area lying between Gampola, Kadugannawa and Peradeniya. Meetings and demonstrations have been held in 30 villages, and some 89 small-holders have undertaken to work their tea lands as advised by the Small-Holdings Officer. So far, of these 89 small-holdings,

good progress has been made in 23, fair progress in 22, but very little has been done in the remaining 44. This last figure is at first sight very disappointing, but to view it in the right perspective, one must take into consideration the conditions prevailing during the period. During the early months climatic conditions were unsuitable for planting green manures or supplies, general cultivation or pruning. Then followed the paddy work which will always take precedence over the work in the tea holdings. Lastly, the price of tea has been such that work in the holdings has not been regarded as worth while, particularly where labour is hired for the purpose. With the recent increase in the market value of green leaf there is more work being done in the holdings and there can be little doubt that if the price of tea can be maintained at an economic level, much better progress will be reported.

Turning to the brighter side of the picture, it will be seen that progress has been made in about 50 per cent. of the holdings even under these adverse conditions. Moreover, these holdings are distributed through 30 villages each of which contains at least one holding in which the methods advocated by the Institute are being carried out. The Small-Holdings Officer visits these villages each month and endeavours to keep in close touch with all small-holders, to advise where necessary and to demonstrate his methods whenever possible.

Of the 89 small-holdings referred to above, 51 are worked with hired labour and 38 by the small-holders themselves. Of the 23 small-holdings which are reported to have made good progress, 10 used hired labour. By expressing these results as percentages, it becomes evident that 34 per cent. of the holdings worked by the small-holders themselves are reported as having made good progress with their work as compared with 20 per cent. when hired labour is used.

Such an observation is not altogether unexpected as the amount of hired labour that can be employed is dependent largely upon the proceeds of the sale of green leaf. As the price falls below an economic level, work in the holdings is diminished until plucking

alone is carried on. The neglect or otherwise of a holding, particularly when hired labour is employed, is dependent upon the value of the crop, and it is to be expected that the recent advance in price will be reflected by increased work in the holdings.

The sale of coupons by small-holders will depend upon the prices realised for their leaf and it is probable that the recent increase in price has done more good than any amount of propaganda against the sale of coupons. There will be no lack of inducements to small-holders to sell their coupons from individuals who hope to make a substantial profit between the purchase and resale, but it is equally certain that counter arguments will be used by the green leaf factories and middlemen.

It should not be assumed that because the sale of coupons is legalised that consequently all small-holders' coupons will be sold and the holdings neglected. With the sale of coupons legalised and the right used rationally, the small-holder has, during the tea control, an opportunity to materially improve his holding and if shown how to make the best of this opportunity, there is every reason to believe that the small-holders' position can be materially strengthened and that he will not be obliterated as the result of Tea Control.

HALF-YEARLY REPORT OF THE SMALL-HOLDINGS OFFICER.

(January-June 1933).

MEETINGS AND LECTURES.

Twelve meetings of small-holders were held during the period under review in Uda-Palata and Uda-Nuwara. At these meetings talks were given on the usefulness of cultivating green manures and cover crops on holdings, the "Lock and Step" drain and "Rim-Lung" pruning. The Village Minor Headmen rendered valuable assistance in organising these meetings.

DEMONSTRATIONS.

During this period thirty-one small-holdings were visited for demonstration both in pruning and draining. I found that personal supervision and talks with the small-holders the best method of giving them assistance. It is at these meetings that one could convince the small-holder of the importance of doing things correctly and gaining the advantages of systematic cultivation.

VILLAGES REVISITED.

The undermentioned villages in Uda-Nuwara and Uda-Palata are being visited monthly for the purpose of finding out what progress is being made with the different works and to afford every assistance to the small-holder.

Uda-Palata.	Uda-Nuwara.	Nawalapitiya.
Attabage-Udagama.	Aludeniya.	Mr. C. E. Kelaart's Property.
Angammana.	Ambanwella.	Mathugama.
Bowella.	Bambaradeniya.	Havelock Estate.
Doluwe.	Ganhatha.	
Dunukeulle.	Geli-Oya.	
Hindagala.	Gadaladeniya.	
Harakolla.	Hendeniya.	
Kalugommuwe.	Imbuldeniya.	
Kirinde.	Kossine.	
Lagundeniya.	Laganmuwa.	
Naranvita.	Polgahange.	
Thelihuma.	Talawatura.	
	Wegiriya.	
	Welligalle.	
	Wellambodde.	
	Wattappolla.	

Good progress has been made with the different works and there is in every one of the villages mentioned above a small area which is worked under my guidance. It is hoped that in time these plots will become model holdings and become permanent demonstrations to the surrounding small-holders.

GREEN MANURES.

The advocation of green manures has been accompanied by the supply of seed from the Institute at cost price and many have taken the opportunity afforded in establishing more green manures. Seed and green manure cuttings have in many instances been supplied *gratis* by the Superintendents of neighbouring Estates; there has always been willing co-operation on the part of Estate Superintendents to afford every assistance to the small-holders who seek their advice.

GENERAL.

Considerable improvement in the condition of some small-holdings has been achieved by frequent visits and demonstration work.

Increased progress could have been made if the prices paid for green tea leaf during the past six months left the small-holder with any working profits. Some small-holders employ hired labour and others do the work themselves. In neither case has the work proved remunerative at existing prices and the result is shown in the tendency to neglect the holdings.

With tea restriction and the issue of coupons it is difficult yet to say what the small-holder will do. The small-holder has been consistently advised not to sell his coupon and cripple himself.

I doubt that there will be much sale of coupons if prices keep on improving. It will only be the man in debt who will sell his coupon, the others will improve their much neglected holdings, making use of the better prices expected with restriction.

I must once again tender my thanks to the Chief and Minor Headmen of Uda-Palata, Uda-Nuwara, Kotmale and Yati-Nuwara, also to all Estate Superintendents for the co-operation in my work with the small-holder.

(Sgd.) R. L. ILLANKOON,
Small-Holdings Officer.

July 11, 1933.

REVIEW OF THE WORK OF THE SCIENTIFIC STAFF.

The following review relates to the quarter ending June 30th, 1933:—

The Biochemist (Dr. D. I. Evans) proceeded on leave preparatory to retirement on April 4th. The Entomologist was granted 3 months' leave abroad from April 18th for health reasons, and the Agricultural Chemist was absent from May 8th till June 2nd owing to ill-health.

Fifty-one consignments of nettle grubs were received for examination during the quarter as against 107 sent in during the corresponding period last year. An examination of the monthly returns made by estates indicates a marked decrease of this pest both in the number of outbreaks and in intensity of attack. Weather conditions, parasites, 'wilt' disease and control measures, such as hand picking and spraying which have been practised on a larger scale than hitherto, have together contributed to the decrease of this pest in Uva.

The life-cycle of *Thosea cervina* was completed for the first time in captivity. The eggs, which were deposited singly, hatched within 10 days. The larval period varied from 37 to 50 days and the pupal period from 39 to 74 days. It would appear that five moults occur during the larval period but it was found impossible to determine this point accurately as the larvae moulted at night and fed on the cast skins. From egg to adult stage the life-cycle occupied from 96 to 124 days.

Experiments carried out with lead arsenate as a stomach poison applied to seed bearers and young tea not in bearing, indicated that any mortality caused amongst nettle grubs was due more to its repellant effects thereby resulting in starvation than to its toxicity. Soap solutions found so effective against *Natada nararia* (Fringed nettle grub) at dilutions of 1 lb. soap to 30 or 40 gallons of water failed to be effective against the larger sized larvae of *Thosea cervina* and *Parasa lepida*.

The first year of the pruning experiments were completed during the quarter and an examination of the data indicate the following provisional conclusions:—

At St. Coombs there was no significant difference between the yields during the first year of plots pruned in April and August, but a smaller yield was harvested from the plots pruned in December. The clean pruned plots gave in general somewhat higher yields than those cut across or 'rim lung' pruned. At Peradeniya there was no significant differences between the yields of plots pruned by these three methods but at Galatura the cut across plots yielded more than those rim lung pruned which in turn gave higher yields than those clean pruned. It is evident from the observations made during the first year from pruning that, if yield alone is to be taken as a criterion of a pruning method, a method which gives the best result up-country will not necessarily give a similar result at a lower elevation.

An experiment to determine the relative merits of four methods of handling young tea has been started at St. Coombs and preparations have been made for other experiments to determine the effect of resting after pruning and the effects of variation in length of the plucking round.

It has been observed that one year of selective weeding, in an area on St. Coombs used for varietal trials, has resulted in a good cover of *Cassia mimosoides*; this cover died out during the dry weather but re-appeared abundantly later from the self-sown seed.

In the Agricultural division, advantage has been taken of outside assistance to establish a cropping trial on a neighbouring estate, wherein four species of bush green manure (*Tephrosia candida* and *Tephrosia vogelii*, *Crotalaria anagyroides* and *Crotalaria usaramoensis*) are being tested under a fourfold replication. The aim is to provide from yield weights and nitrogen analyses a practical demonstration of the most advantageous time for lopping and burying the green crop. Analogous data is also being accumulated at St. Coombs.

The provision of a thoroughly satisfactory method of determining the mechanical analyses of tropical soils, has been engaging the attention of the Imperial Bureau of Soil Science for some time.

An adequate technique has now been published and the examination of the soils accumulated in the Agricultural division has been started. It is satisfactory to report that the new method involves a much shorter period of mechanical shaking than its predecessor. Owing to restriction of power on St. Coombs due to economic considerations, the long period of shaking formerly necessary had made the progress of work of this nature impossible.

A feature of recent inquiries has been the occurrence of several cases of deterioration of tea on areas which examination has shown are mainly remarkable for the high manganese content of the soil. In conjunction with the Plant Physiologist a study of manganese toxicity has been put in hand.

In the Biochemical division, on the factory side, work has been concentrated on a thorough overhaul of the experimental machinery. Improvements to the existing roll breakers and rollers have been put in hand as a result of a comprehensive series of tests on the performance of the machines. It is intended to standardise the batteries of experimental machinery as completely as possible and thus increase the accuracy and comparability of the plant.

In conjunction with the Superintendent, a study of the winnowing of tea has been started.

C. H. GADD,
Acting Director

MINUTES OF A SPECIAL MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON.

A Special Meeting of the Board of the Tea Research Institute of Ceylon was held in the Grand Oriental Hotel, Colombo on Tuesday, 30th May 1933 at 4-30 p.m.

Present:—Mr. R. G. Coombe (Chairman), the Hon'ble the Financial Secretary (Sir Wilfrid Woods, C.M.G.), Col. T. G. Jayewardene, Messrs. B. M. Selwyn, C. E. Hawes, D. H. Kotalawala, M.S.C., R. D. Morrison, D. T. Richards, Jas. Forbes (Jnr.), John Horsfall, I. L. Cameron, A. W. L. Turner (Secretary) and by invitation Dr. C. H. Gadd (Acting Director, T.R.I.).

Absent:—The Acting Director of Agriculture.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 14th April, 1933, were confirmed.

The Chairman explained that this Special Meeting had been called to discuss the Report of the Sub-Committee appointed by the Board at the Meeting held on the 14th April, 1933. The matter was urgent because it was necessary for the Report to reach the Ceylon Association in London before its Meeting on June 26th. Otherwise it could not be considered by that body until September.

He stated that the present cess of 14 cents would expire at the end of the current year, and that it would be useless to ask the State Council to authorise the retention of the cess at that figure unless the application was supported by the Ceylon Association and other proprietary interests. He added that copies of the Report had already been sent to Major Oldfield, Dr. R. V. Norris and Mr. John Still.

It was agreed that the Report should be discussed by sections. After a full discussion of all sections, Mr. Selwyn remarked that the Report was an extraordinarily able document and he proposed that it should be adopted as presented.

Mr. Richards seconded.

The motion was carried, Col. Jayewardene alone dissenting.

It was further decided that the Ceylon Association in London be informed of this decision as early as possible and that the Report be submitted to the Planters' Association of Ceylon, the Ceylon Estates Proprietary Association and the Low-Country Products Association for their comments.

Mr. Selwyn undertook to obtain an expression of opinion at the next Meeting of the General Committee of the Planters' Association in July.

Sir Wilfrid Woods pointed out that the Board's decisions on this Report were dependent on the proprietary interests' sanction regarding the cess being obtained.

The Meeting endorsed this view.

It was further decided that if the proprietary interests approved of the Report, the Institute should approach the Minister for Agriculture and Lands and ask him to put the matter through the Financial Secretary's Department for presentation to the State Council with the least possible delay.

It was also decided that Mr. G. K. Stewart, M.S.C. should be asked to explain the situation in the State Council.

After passing a vote of thanks to the Special Sub-Committee and a vote of thanks to the Chair, the Meeting terminated.

A. W. L. TURNER,

Secretary.

METEOROLOGICAL OBSERVATIONS.

JANUARY-JUNE, 1933.

	Temperatures				Mean Relative Humidity.	Rainfall Inches.	No. of Rainy Days.	Hours of Sunshine.
	Mean Max.	Mean Min. air.	Adopted Mean.	Mean on Grass.				
January	70·7	59·1	64·9	57·1	79	11·15	24	101·6
February	75·2	54·5	64·9	49·9	64	0·49	8	211·57
March	77·0	55·0	66·0	49·7	67	3·60	13	256·44
April	77·1	57·1	67·1	53·6	78	6·82	15	231·58
May	71·5	59·3	65·4	57·7	85	36·44	30	79·9
June	69·2	59·6	64·4	58·4	77	9·54	27	109·31
	73·5	57·4	65·5	54·4	75	68·04	117	990·25
	Means					Totals.		

NOTICE.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Staff may not be free to show them round. Such visitors, on arrival at the Factory, are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

EDITORIAL.

As most of our readers are aware the question of the rate at which the Tea Research Institute Cess shall in future be levied is now under consideration. In view of much misunderstanding on this subject it seems desirable to state briefly the real facts of the situation.

The income of the Institute is derived from two sources only—(a) Profit derived from the estate and (b) The proceeds of the export cess which at present is levied at the rate of 14 cents per 100 pounds tea.

Equally with estates all over the Island the Institute has suffered from the slump in tea prices and this fact, coupled with the necessity which still remains for development work, makes it obvious that until conditions become more normal the *nett* revenue to be derived from the estate and available for research activities must be at a much lower figure than was considered probable in 1930. In fact it is clear that the Institute must depend for some 95 per cent. of its income on the proceeds of the cess alone.

Under normal conditions the income from the cess might have been expected to show a slow but steady increase. With the imposition of restriction, however, the position has undergone a radical change, the effect of a 15 per cent. restriction of crop being to reduce the proceeds of the cess by approximately Rs. 50,000 per annum.

In these vastly changed circumstances it cannot, therefore, be considered surprising that the forecast of the Institute's probable income made in 1930 has proved wide of the mark and that it has become necessary to reconsider the whole position in regard to the Institute's future requirements.

For the three years 1931-1933 the cess has been levied at the rate of 14 cents per 100 pounds but this rate will fall to 10 cents as from January 1st, 1934, unless the Ordinance be further amended.

The cumulative effect of such a reduction and of restriction of exports on the Institute's finances will be clearly seen from the figures below showing the anticipated yield from the cess in the next five years. These figures are based on the assumption that restriction will be at the rate of 15, 12½, 10, 10 and 5 per cent. during the restriction period.

Estimated Income from Cess, 1934—1938

Year.		Cess at 14 cents. Rs.	Cess at 10 cents. Rs.
1934.	...	305,918	218,513
1935.	...	314,717	224,655
1936.	...	316,918	226,370
1937.	...	330,122	235,800
1938.	...	347,730	248,358
	Total.	Rs. 1,615,405	Rs. 1,153,696

The falling off in receipts from the cess if reduced to 10 cents is, on the above basis, shewn to be Rs. 461,709 and could only be met by a most drastic reduction in the Institute's activities.

The Institute has, therefore, asked that the cess shall be retained at the present figure of 14 cents. This figure is considered essential in order

(a) To cover annual recurrent expenditure.

(b) To allow of annual provision for depreciation.

(c) To provide for the gradual formation of a general reserve fund from which capital expenditure can in future be financed.

Recurrent Expenditure.—In addition to Research Revenue Expenditure which is estimated at Rs. 191,055 in 1934, rising to Rs. 209,882 by 1938, it should be remembered that the Institute has to repay annually to Government a sum of Rs. 78,227 being interest charges and repayment of the loan made by Government to finance the starting of the Institute.

Depreciation.—Though the assets of the Institute, buildings, plant, etc., have been written down in the balance sheet by a sum which at December 31st, 1933, will amount to approximately Rs. 165,000, the financial position has not, prior to the present year, permitted of the formation of any *cash* depreciation reserve from which replacements could be effected. This is obviously undesirable and future estimates allow for the annual provision of approximately Rs. 28,000 for this purpose.

Capital Expenditure.—Just as it has hitherto been impossible to form any cash depreciation reserve so it has been equally impossible to accumulate any general reserve from which capital expenditure could be met and such expenditure has at present to be financed from revenue account. Capital expenditure in the next five years is estimated at Rs. 90,215, Estate Account Rs. 56,340 and Research Account Rs. 33,875, and it is proposed that this shall be financed by transferring any surplus on revenue account to a general reserve fund established for this purpose.

On the above basis the expenditure during the next five years is estimated to be as follows:

Year.	Expenditure on Revenue Account.	Capital Expenditure
	Rs.	
1934.	297,087	
1935.	294,820	Rs. 90,215
1936.	305,732	
1937.	311,784	
1938.	316,965	

One has only to compare these figures with those given earlier for the cess yield to realise that a cess at 14 cents is essential if the activities of the Institute are not to be materially curtailed. In this connection it should be pointed out that the draft budgets for 1934-1938 on which the figures given are based already

allow for a reduction in Staff from 1935, and any reduction in the cess rate at the present time can only be reflected in further cuts which must materially reduce the Institute's efficiency.

The Institute's proposals have received the support of the Ceylon Association in London, the Ceylon Estates Proprietary Association and the Planters' Association. It may fairly be claimed, therefore, that they are backed by the financial interests concerned and the practical planter and it is hoped that the necessary amendment to the Ordinance will shortly be passed.

It is realised that the present time is a difficult one in which to make further calls upon the Industry. It may not be out of place, therefore, to touch very briefly upon the other side of the picture and to indicate one or two directions in which the Industry has already received direct financial benefit from the work of the Institute. Space will only permit of reference to a very few instances.

The work of Dr. Gadd on the so-called Diplodia disease in the Low-country, proving that this was due to a deficiency in the starch reserves of the bush and could be prevented by lighter pruning and resting, has resulted in the saving every year of thousands of bushes which would otherwise have been lost.

This has been followed up by the investigations of the Plant Physiologist on the influence of different types of pruning on dieback at low elevations. In these experiments the saving effected by the use of rim-lung pruning instead of clean pruning worked out at Rs. 59 per acre, the value of the bushes saved, while in addition the method resulted in a greatly reduced amount of damage to the frames by dieback

Manurial experiments are naturally long range work and the work of the Institute in this direction is still in a relatively early stage. It is safe to say, however, that without the advice and backing of the Institute the substitution of inorganic fertilisers for the more expensive organics would not have been attempted on anything

approaching the scale that has in fact occurred. The saving already effected on this item alone would cover the working expenses of the Institute for a good many years.

The insistence of the Institute on measures of soil conservation and amelioration and the use of green manures and cover crops is slowly having its effect on estate practice and the cumulative effect of this work in maintaining the capital value of estates will undoubtedly be very large indeed.

In regard to manufacture few will question the benefit which has resulted from the advisory work of the Institute and the value of the Institute's publications on this subject has received universal recognition.

The increasing number of enquiries which the Institute now receives in every branch of estate work is in itself evidence that planters do attach value to the services of the Institute. It is naturally difficult to assess the immediate value of such advisory work but one example can be quoted in which the advice tended prevented an expenditure of some four lacs of rupees which would undoubtedly otherwise have been incurred and which would have been entirely unproductive.

The above few examples naturally give little idea of the scope of the Institute's activities. A large proportion of the work is of a long range nature and immediate results cannot reasonably be expected. It is perhaps difficult for a layman to appreciate and make due allowance for this and this fact no doubt accounts for much of the criticism directed against this and other similar Institutes. In this connection we may conclude by a quotation from Julian Huxley's "Africa View" dealing with the work of the Amani Research Station.

"Meanwhile a good deal of hasty criticism has been passed on Amani by public opinion in East Africa. 'What has Amani done for African Agriculture ?' is the sort of question you hear asked; and unofficial members of the Legislative Councils demand that its subvention shall be cut down or discontinued altogether.

"The answer to such criticism is that no one who was not either foolish or uninformed would expect Amani to have done a great deal for the practice of African agriculture in the very few years since it was re-established under British control. In the first place, the necessary new laboratories have only been finished this year, and the full complement of staff has only just been made up. In the second place, how can anyone expect pure scientific research to have its repercussions in practice in a year or so? The effect of scientific research of a fundamental nature is, and must be, slow but cumulative. If anyone wants proof of this, let him study the history of the Dutch Research Station at Buitenzorg, in Java, and the progressively expanding benefits which it has conferred upon the prosperity of the tropical possessions of Holland."

The remarks made apply with equal force to the Tea Research Institute. It is only three years since the Institute has had proper facilities for its work and three years is a very brief period in the history of research, particularly in the case of a permanent crop such as tea.

ROLAND V. NORRIS.

SOIL EROSION—III.

T. EDEN.

THE EFFECT OF GROUND COVER AND LITTER.

Measurements of loss of fertility in soils subject to erosion are closely linked with the actual loss of soil. Numerous data are available showing how serious this can be, the difficulty in interpreting such figures being that the conditions responsible for the losses vary considerably from place to place according as climate, topography and soil type themselves change. These aspects of the problem will be referred to in their turn but the most important practical feature of soil erosion studies will always be the relationship of the crops grown to the severity of the loss. In the present section of this article three related features will be dealt with: the nature of the crop, the effect of living ground cover, and the effect of debris shed by the crop or crops under cultivation.

THE SPACING OF THE CROP.

One of the most prevalent fallacies regarding soil erosion in Ceylon is that a good covering of tea offers adequate protection. This is demonstrably not the case. Granted that the beating action of heavy rain is minimised by the foliage, such protection as this affords leaves untouched the question of the rate at which the bare soil beneath can absorb the rain which ultimately reaches it. So long as the percolation rate of water through the soil remains less than the precipitation rate at the bare ground surface soil erosion is bound to occur in varying degrees of severity on sloping land. The only remedy is to *fix* the soil.

Interesting figures dealing with liability to erosion of various types of crop are given by Bates and Zeasman at Wisconsin. From measurements of run-off over a period of years they arrived at the following average figures for different types of crop, expressed as the percentage of rain that ultimately became run-off. Forest land

Forest	...	2·8	Small grain	...	25·6
Wild pasture	...	7·2	Maize	...	25·7
Cultivated hay	...	17·7	Seeded pasture		26·7

stands in a class apart; it combines high and ground cover and a layer of litter about which more will be said later. Natural pasture is highly efficient, but all forms of cultivated crops, no matter how closely planted, allow of considerable erosion. This is understandable when one considers that during part of their growth a large part of the superficial area over which they are distributed is really bare fallow. A crop of the maize type regularly spaced is a poor protection in spite of its leafy growth, giving as it does the opportunity for a quarter of the total rainfall to appear as soil-transporting run-off.

These results do not stand alone; they are remarkably confirmed by the classic experiments at the Missouri Experiment Station over a period of six years. On these plots where a useful comparison can be made they agree well with the Minnesota results.

Run-off as Percent Rain.

Grass Sod.	...	11·55
Wheat.	...	25·19
Maize.	...	27·38

To return to the consideration of tea; here is a widely planted crop regularly denuded of foliage and having a relatively complete cover for only a limited time. Even at this favoured period, for reasons outlined above, the bushes' efficiency in the preventing of erosion is far from satisfactory. In short, to rely upon tea foliage to prevent erosion is to turn a blind eye to the necessities of the situation.

LITTER AS A PREVENTATIVE.

There is no need to press further the claims of ground cover as the best control measure, and attention will be directed to some new and remarkable work on the effect of litter from trees on soil and water movement. Investigations have been in progress for some time at the Forestry Research Station, California, on the percolation

of rainfall through forest soils. Lowdermilk transferred forest soil layer by layer into a series of specially constructed tanks which were subjected to artificial rain falling at known rates for various time periods. The whole apparatus is a model of careful conception, allowance being made for collecting and measuring run-off and percolation water with considerable refinement. After allowing time for settlement of the soils in the tanks, the leaf mould litter on the surface of half of them was carefully burned off by means of a blow-lamp torch. The results from no fewer than eighty trials are summarised below.

Surface Run-off as percentage of Run-off and Seepage 200 inches artificial rain.

Soil Type.	Aiken.		Holland.		Altamont.	
	Burned.	Unburned.	Burned.	Unburned.	Burned.	Unburned.
70 runs 1927.	30·7	3·5	31·2	13·0	47·8	4·1
10 runs 1928.	38·7	0·7	40·8	21·9	62·6	1·3

Though there are differences in detailed behaviour between the three types of soil, to which reference will be made later in dealing with soil erosion on different kinds of soil, these data are consistent in showing how little run-off the naturally littered soil allows. This in itself severely restricts the amount of soil that can be removed, besides curtailing the opportunity for such run-off as occurs to become loaded with soil particles.

A STUDY OF PERCOLATION RATES.

But the results are chiefly of interest because of Lowdermilk's explanation of the phenomenon. Is the decrease in run-off due simply to the sponge-like capacity of the litter ? That can hardly be the case since even in the less favourable instance of the Holland soil the litter would be compelled on this hypothesis to hold up between 60 and 70 inches of rain. Lowdermilk showed that the absorption capacity of the litter was experimentally insufficient to

retain the apparent run-off deficit, and suggests that the litter, by keeping the soil underneath porous, enhances its natural capacity for percolation. In order to demonstrate this he percolated ordinary soil with clear water first and with muddy water afterwards. The result was a 90 per cent. diminution in percolation within six hours of using the turbid water; the seepage remained clear. On reverting to clear water no improvement was observed. This confirms his view that in the absence of litter the small clay particles of the soil are washed down into the soil pores and become a filter. Such a filter even though insignificant in thickness would completely determine the percolation rate of the soil underneath. On Lowdermilk's explanation the percolation effect of litter becomes of greatest importance whilst the absorption effect takes only a secondary place. In Czecho-Slovakia similar results have been obtained. After complete saturation of the litter the percolation through the soil remained undiminished. Further work at the Central States Forest Experimental Station, U.S.A., bears out the results of these investigations. The percolation of water through littered forest soil and similar unlittered agricultural land was measured depth by depth. Taking the agricultural soil as unity there were remarkably superior percolation rates on forest soils.

Depth, inches.	Percolation rate of forest soil: agricultural soil at unity.
1	50
3	17
8	2·5

Further investigation showed that it was not necessary to go to the length of completely denuding the land by agricultural operations in order to destroy the percolation effect. Grazing in forest soils had an effect just as marked.

This work brings out a new and important point—that litter, by which is meant unhumidified vegetable remains, has an effect in inducing rapid and continuous percolation that even richly supplied humus soil cannot equal, and that as a corollary litter counters soil erosion effectively and preserves the underground water supplies for use in drought conditions.

GREVILLEAS IN TEA.

The point of contact of this work with tea culture is, it seems to us, the use of the Grevillea. It is a matter of constant comment that the Grevillea cover in many planting districts has of late years been severely depleted and to many planters this is now a matter for regret. The arguments for and against Grevillea must be thought out by individuals to suit their local requirements, but direct observation and the experiments just quoted make it certain that its use offers a positive contribution not only to soil erosion prevention but to porosity and aeration of permanently cultivated land.

LARGE SCALE MANURING TRIALS.

T. EDEN.

The "Times of Ceylon" of November 6th, published an account of a series of three manurial trials carried out under estate conditions under the auspices of the local branch of Imperial Chemical Industries, Ltd. As the Tea Research Institute has received a number of enquiries relating to these trials and has been asked to define its views on the subject, it seems probable that an article embodying these views and discussing related subjects may be of general interest.

The settled policy of the Tea Research Institute is not to have any formal relations with concerns that market fertilisers, by which is meant that none of the manufacturers or distributors of the fertilisers used in the Institute's field trials subsidise, by even so much as the gift of a bag of manure, the conduct of these experiments. This policy has conceivably certain disadvantages, one of these being that it makes it almost impossible for the Institute to try out in advance new types of fertilisers before they become generally available on the market. The outstanding advantage of our attitude, however, is that it makes abundantly clear our independence of action and of judgment. The initiative in all trials and the decision as to what shall be done lies solely with an executive Experimental Committee upon which members of the Board, the Scientific Staff, the Estate Superintendent, the Visiting Agent and a leaven of practical planters act in concert, with power to co-opt technical opinion in the form for instance of an advisory engineer and tea-taster.

Outside our own activities, the Institute manifests great interest in all experimental work, maintained by other bodies, that is brought to its notice. Should any estate or company desire to experiment on their own account, the Institute is anxious to put its technical knowledge at their service and this policy is not entirely exclusive of those whose perfectly legitimate occupation is to market fertilisers to the planting community. Occasion has arisen in the past for comment on the proposed trials of fertiliser manufacturers

when these have come to our notice. The aim has been to ensure as well as possible that experiments which will ultimately be used to recommend specific manures to planters shall be free from objectionable features which would endanger the reliance that could be placed on them. In this way we strive not only to place reliable data of our own in circulation but to safeguard consumers from unwitting misinterpretation of trials with which we can have no official connection. Such trials are the responsibility of the interested parties and cannot claim the imprimateur of the Institute.

The form that these private trials usually take is that of the relatively simple large-scale trial under estate conditions. The Institute itself does not prosecute this type of work and has on that account sometimes incurred criticism. There are excellent reasons why our activities should not take this form. If the resources of the Institute were unlimited large scale work might ultimately come within the bounds of possibility, but as they are not we concentrate on the smaller scale trial. The small scale trial is not, however, a *pis aller*, it is actually the keystone of all experimental work, because it aims at an unimpeachable accuracy. A large scale trial supported by small scale experiments of known accuracy is on a vastly better footing than a large scale trial as a unique effort. There appears to be a magic attraction in the words 'large scale' which they by no means warrant. In an industry where the word quality is on every tongue there should be no need to emphasize the fact that the usefulness of a field trial depends not on size and quantity preeminently, but on the quality of the workmanship that goes into it. In short, we do not conduct the more exacting small scale experiment for abstruse reasons,—the large scale trials, as trials, would be far simpler to carry out and supervise,—but because the cumulative experience of many years has shown the absolute necessity of this manner of approach.

Turning now to the actual experiments that prompted this review of policy, they aim at comparing and contrasting the action of organic nitrogen, and to some extent organic phosphorus compounds, with

equivalent quantities of purely inorganic constitutents. The three trials embrace different ratios of manurial constituents, different pruning cycles and implicitly different elevations and climatic conditions. Taking them at their face value they demonstrate a probable superiority in yield for the inorganic fertiliser, and no inferiority in price value. How far are we justified in taking them at their face value ? It is possible that the disposition of the plots has favoured the yields for inorganic manures, and that the superiority of the inorganics is due to initial plot differences. This possibility is diminished as the number of trials increases; the odds against such an assumption are calculable and in this case are 7 to 1. Had the series been a four trial one, giving the same type of result, the odds would have been 15 to 1. As odds are counted in the sporting world these figures are high, but the standard to which the Institute's experiments adhere are never less than 20 to 1 and are frequently higher still. In our opinion the quality determination is of rather better standing than that for yield, because although a superiority in intrinsic fertility of a plot may give better yields to a plot independent of its manurial treatment, it is less likely to affect the quality factor. In fact as experience multiplies, it seems more and more likely that any increase in yield (other conditions being equal) tends to work in the direction of minimising quality rather than otherwise.

The longest period involved in these trials is a year and four months, but they are to be continued. The Institute in carefully controlled trials of a similar nature now has three years' results and so far no difference between organic and inorganic manures has appeared. We submit that our trials provide a background against which these large scale trials may be judged. We should be glad to see more trials of this type in Ceylon. They would strengthen the chain of evidence that is being built up in the hope of settling this question one way or another; meanwhile the problem is nearer to solution than it has been aforetime.

If one is reasonably satisfied that no gross fallacy in method occurs in these two types of trials, though one waits for further work

in confirmation, there can be no question of dismissing them off-hand. One cannot have the cake and eat it by discounting the usefulness of small scale work and equally neglecting the only large scale data available. An attempt should be made to weigh the data on their merits and not to condemn them as a correspondent has done in the press by finding bad reasons for preconceived convictions which he really holds on other grounds. Data publishd in good faith must be answered by other data, and not by drawing on the imaginative stock-in-trade of Baron Munchausen and pleading intoxication by inorganic manures and the superiority of supplying nutrients in the 'natural form' of organics. The superiority of organics is the question that lies in the balance, and as indicated above it is still *sub judice*, but nothing is more certain than that organic nitrogen is not the natural form in which plants absorb their foodstuffs, which knowledge, it may be added, is now more than half-a-century old.

THE TEA TORTRIX (*HOMONA COFFEAREA* Nietn).

C. B. REDMAN KING

INTRODUCTION.

After Termites, the Tea Tortrix may be considered the most important pest of tea in Ceylon. When severe, the bushes have a ragged, untidy appearance, and a large proportion of the flush is attacked by the caterpillars which web together the buds and young leaves, so rendering them unfit for plucking; and the worst attacks usually take place at a time when the best quality tea is expected.

As methods of control must be based on facts connected with the habits, life and seasonal history of Tortrix, the more important information about these is set forth. Control methods in the past have been concerned with handpicking the eggmasses and larvae, "flight breaks" and spraying, and in the present with biological control. These are discussed in some detail.

A systematic description of the male and female moths of Tortrix is not given here, but the reader interested in the technical aspect will find it at the end of Jardine's paper on Tea Tortrix [10].

HISTORY.

The insect known as Tea Tortrix was first described by Nietner in 1861. It was at that time found on coffee, but did not apparently do much harm. Subsequently, coffee in Ceylon was replaced by tea, and in 1889 came the first extensive outbreak [4], confined to Dimbula and Dikoya. Ten years later, there was another extensive attack in the same districts, and also in Pundaluoya and Ambegamuwa. After this, it appeared in numbers every year up to 1906, being worst in Maskeliya in 1903. From 1907 to 1910 there was a lull, but since then it has reigned as a first class pest of tea. The record shows that severe attacks are limited to some of those tea districts which are subject to the south-west monsoon rains.

DISTRIBUTION.

Although the distribution of *Homona* in Ceylon is fairly wide, it has only appeared as a severe pest in the denser part of the tea belt between Adam's Peak and Nuwara Eliya, and northwards to the Hewaheta district. It does occur in most other tea districts, but is comparatively scarce, so that in a great many places it hardly attains the status of even a minor pest. It does not appear on estates about Nuwara Eliya itself, so that its range as a pest would lie somewhere between 3,000 and 6,000 feet.

Apart from Ceylon, it appears in Formosa as a pest of first importance on tea, and in Northern and Southern India, Java and Indo-China as one of the lesser importance. The "flushworm" of South India is not the same as Tea Tortrix, being an Eucosmid moth, *Laspeyresia leucostoma* Meyr.

LIFE HISTORY.

Adults.—The female moths, of variable shades of brown, are considerably larger than the males. When common, they may be often seen resting on the upper surface of the tea leaves, and are readily taken by hand. The males are much more lively, and on

approach dart rapidly away, coming to rest a few bushes off, in a characteristic zig-zag flight which may be repeated as often as the observer draws near.

Eggs.—Mating probably takes place soon after emergence, which mostly occurs at sundown or a little after. Fertile eggs may be laid the first evening after emergence in compact masses, and the eggs being flat overlap one another. The number laid in one mass is very variable, being as low as 10 or as high as 500, but the average is about 130. However, the females are capable of laying two egg-masses though I have never had one which laid on more than two occasions. The eggmasses are always laid on the upper surface of leaves where they are quite conspicuous. The female moths appear to like shiny surfaces on which to oviposit, for they have been found on such plants as arum lilies and palms, on which the larvae make no attempt to feed. Eggmasses are also commonly found on window glasses, to which the moths may have been attracted by light in the first place.

The colour of a freshly laid eggmass is a pale-yellow, more or less uniformly distributed to the naked eye. As the age increases, the embryos grow, making the whole mass become darker, and later the yellow colouration becomes deeper with a tint of orange. Later still, a day or two before hatching, rows of little black dots appear, which are the heads of the caterpillars within, and after a total period of about eight days (but the period varies with the temperature from six to eleven days) the larvae hatch out.

Larvae.—Once out of the eggs, they race away in all directions, the agility they display only being equalled by the urgent need they appear to feel to remove themselves as quickly as possible from the scene of their birth. The majority fall over the edge of a leaf and hang by silk threads, and so may reach a lower part of the bush, but if any reach the petiole they crawl along the stem. Owing to their vigour and speed of movement they may travel a long way from their starting point. After reaching a suitable spot they may start to feed within three hours of hatching, but they are capable of holding out for a long period without food.

Owing to their rapid migration it is a difficult matter to trace all the individuals which have hatched from an eggmass, but subsequent observations lead one to suppose that a considerable number become casualties at an early stage. A few will find their way to young shoots, where at first they pass quite unobserved, owing to their small size and to their colour. It seems probable that they may then suffer considerable losses at the hands of pluckers who remove them with the shoots unnoticed.

The survivors, having webbed round themselves the edge of a leaf, or two leaves together, feed inside the shelter thus made. This retreat helps to serve as a protection against the ills that may befall them. Their leafy home soon gets eaten out and discoloured, and the caterpillars then remove to some other place and repeat the process. If the spot happens to be a shoot, they web together the bud and first leaf, and perhaps the next leaf or two, according to the size of the caterpillar. If the caterpillars are numerous, the bush shows the characteristic untidy appearance, evidence of their recent presence, and there will be some loss of crop.

The majority of larvae have black heads, but a small proportion are brown in this respect. There does not appear to be any significant difference between the two varieties. The body colour is at first yellow, later becoming either green and translucent, or white and opaque, and when full grown measure about one inch in length. During the period of growth the caterpillars cast their skins several times; the number is somewhat variable, but five is the commonest. Hutson [6] gives 4-6 times in the case of potential males, and 5 or 6 times for potential females.

As a whole the larval stage lasts five or six weeks at elevations over 4,000 feet. Jardine [11] gives four to five weeks and Hutson [6] 18-37 days at Peradeniya (1,500 feet).

Pupae.—When full grown the larvae stop feeding and presently pupate where they are, without making cocoons. This stage at high elevations lasts from 7-10 days. Jardine [11] gives one week and

Hutson 6-7½ days at Peradeniya. These authorities give 6-8 weeks and 5-10 weeks respectively for the full life cycle. At high elevations, 8-10 weeks may be taken as the period.

Emergence.—When the time approaches for the emergence of the adult, the pupa wriggles its way out of its leafy cell until about three-quarters of it is free, and in this position the moth emerges. It may take place at most times of the day or night. I have found sundown and shortly after to be the most frequent, but Hutson [6] gives the early hours of the morning as being the commonest, and sometimes the morning or early afternoon.

An excellent coloured plate of all stages, except the ova, is given by du Pasquier [19].

FOOD PLANTS.

The following is a list of host plants of *Homona coffearea*:—

Tea.
Crotalaria species.
Dadap.
Grevillea Robusta.
Acacia sp.
Eucalyptus sp.
Hibiscus spp.
Roses.
Chrysanthemum.
Acalypha.
Camphor.
Pelargonium.
Inga saman.
Sword bean.
Amaryllis.
Cowpea.
Red Guava.
Citrus spp.
Cacao.
Jak.
Duranta.
Apple.
Quince.
Strawberries.
Cabbage.

The above list can probably be very much extended. Larvae have been taken from all the plants mentioned above, but it does not necessarily imply that moths have laid on all of them; indeed it is often a puzzle to find out whence solitary specimens of the larvae have come.

SEASONAL HISTORY.

From observations made during the four years 1930-1933, supplemented by notes on the subject previous to this time, the annual cycle is taken, for the sake of convenience, as beginning about the middle of the year, when Tortrix is not as a rule common in any stage, but caterpillars will be reaching maturity in August. At this time there usually occurs a break in the weather with sunny periods and higher daily temperatures; this is closely followed by an emergence of moths, and a sudden increase in the number of eggmasses. We may call this the first generation of moths, and it lasts but a few days. Some eight or nine weeks later the second generation is produced, lasting a week or two, the third generation following at about the same distance of time and arising at the end of December or the beginning of January. This third generation is the important one of the year, not only on account of the large number of eggmasses which may be laid, but also, and chiefly, because the attack which follows corresponds in point of time with the flushing of the highest quality tea of the year.

The oviposition period of the third generation lasts from three to four weeks, the number of eggmasses rising suddenly at the start, and falling away as quickly afterwards. In the 1931-1932 season, the period lasted from January 2nd to January 22nd, and in the 1932-1933 season from December 24th to January 23rd. If the third generation is very heavy, a fourth can be discerned in March and a small fifth in May or June, but in the first half of the year, as soon as thundery weather begins, parasites and Wilt make their appearance, so that the caterpillars of the third generation are considerably reduced in numbers. This reacts on the parasites, so that they, too, become numerically weak, and the lag so produced enables the Tortrix to get away again as the year advances.

A full knowledge of the appearance of the different generations should enable the collection of eggmasses to be carried out with greater effect, and this is discussed below under Artificial Control measures.

NATURAL CHECKS.

Wilt.—The chief check on Tortrix appears to be the mysterious disease known as Wilt, which perhaps is to be classed as a virus disease [3]. It occurs chiefly in the warm, moist weather of March onwards, although it is to be found at almost any time. It may be responsible for killing considerably more than half the population; it is very difficult to get reliable figures for this, since caterpillars, if kept in confinement, are very susceptible to the disease if any Wilt is about, and this confinement appears to aid very materially the spread of infection.

Parasites.—There are several parasites, most of which attack the larval stage.

Trichogramma erosicornis is a tiny parasite which develops completely inside the Tortrix egg. Jardine [12] reported the presence of two egg parasites, apparently on the ground that while in some cases only one parasite was reared from one egg, in others more than one were obtained. *T. erosicornis* commonly develops one per host egg, but I have several times reared more than one from a Tortrix egg, the maximum being six, and have never come across another species.

The following is a list of parasites known to date:—

1. Egg Parasites.

   Fam. **Trichogrammatidae**
   Trichogramma erosicornis.

2. Larval Parasites.

   Fam. **Ichneumonidae**
   Phytodiaetus capuae Morley.
   Stictopisthus sp.
   4 unidentified.

   Fam. **Braconidae**
   Microdus sp.
   Apanteles sp.

   Fam. **Eulophidae**
   Tetrastichus sp.

Fam. **Elasmidae**

Elasmus homonae Ferrière.

1 unidentified.

In addition to the above are three undetermined parasites, and two hyperparasites.

3. Pupal Parasites.

Fam. **Chalcididae**

Brachymeria euploae Westwood.

1 unidentified.

The egg parasite is extremely rare when the third generation of moths appears, but may be found from time to time up to about May. Natural parasitism by *Trichogramma* rarely exceeds 0·1 per cent. which is no doubt largely due to the short periods of time when eggmasses are abundant.

The larval and pupal parasites are more common from March to May than at other times. An exceptional season in this respect was the period December, 1932 to February, 1933, when several species were numerous. The commonest at this time appeared to be the pupal parasite *Brachymeria euploae*, which could be seen flying about amongst the bushes in large numbers, a somewhat unusual sight. *Phytodiaetus capuae* was also fairly common then, along with two other unidentified Ichneumonids.

January, 1933, was excessively wet, although this month is most often fairly dry, and appeared to favour parasite propagation. On the other hand, dry weather appears to operate in some way against Tortrix parasites, so that a long spell of dry weather would seem to provide conditions conducive to a Tortrix outbreak.

BIRDS.

A great many birds consume insects as part of their diet, a few perhaps entirely so. Agricultural areas in close proximity to bird sanctuaries, natural or artificial, are kept reasonably free from pests by the inhabitants of these retreats. But the wholesale destruction of jungle in Ceylon to make place for coffee and then for tea has undoubtedly been responsible for a great loss of bird life in these

areas, and may partly account for the prevalence of some insect pests; hence the encouragement of birds by means of sanctuaries would go some part of the way to assist Nature in restoring the previous balance of life. Very large numbers of birds of the right sort might solve the Tortrix problem, but it is questionable whether there is enough unwanted land on estates to provide sanctuaries sufficiently commodious to contain them. On the other hand, small ones might help considerably, and with a view to finding out their possibilities, a sanctuary of about two-thirds of an acre has been started at St. Coombs. It will, of course, take some years to mature. A census of birds taken from time to time should be very instructive, and should throw light on the question of the effectiveness of birds in connection with Tortrix.

ARTIFICIAL CONTROL.

Flight Breaks.—Methods of artificial control must be based on the habits, life-history and seasonal history of an insect. In his papers on Tea Tortrix [13, 14], Jardine recommended the extensive planting of "flight breaks" as a means of coping with the pest. The idea was to create barriers of trees at right angles to the wind, presumably in order that the trees would act as a sort of strainer, and become littered up with the insects borne along in the air. This is based on the supposition that the moth is blown from one place to another by the wind. In the first reference given [13], he states that "The South-West Monsoon is responsible for the distribution of the insect"; in the second reference, "Tortrix Flight Breaks", the first sentence is: "It is known that the South-West Monsoon is responsible for the general dissemination of Tea Tortrix." Unfortunately, no data, nor even a hint of the evidence, is given in support of these statements. If reference be made to the remarks on the history of Tortrix as a pest, at the beginning of this paper, it will be seen that the first recorded outbreak was in Dimbula some fourteen years before Maskeliya suffered in the same way. As Maskeliya is south-west of Dimbula, it is difficult to see how the South-West Monsoon could be responsible for blowing the moths in the opposite direction.

The next sentence after the second quotation above is: "All ridges exposed to this wind are liable to infestation." The inference here is again that the wind drives the moths along, and that they get combed out by the bushes on the ridges. If we suppose for a moment that the wind is responsible for this, whence are the moths blown ? If from sheltered positions, it is hard to see how they could remain in exposed positions. On the other hand, if they are blown out of the exposed positions, how do the latter become most liable to infestation ?

The fact is that there is considerable misconception as to the part that wind plays in distributing insects. Generally speaking, the stronger the wind, the harder do insects cling to their supports; whereas in mild airs winged insects become active, other conditions being favourable, and their tendency, if affected by wind currents at all, is to fly against them. This is not to say that no winged insects whatever are blown along by wind. As an instance, when aphids, or plant lice, grow wings, their migration is certainly assisted by air currents; and in all probability, as they are very feeble fliers, the function of their wings may be, perhaps, more suitably compared with a parachute than anything else. They constitute, however, a rare exception. Even a small insect like *Trichogramma* appears to owe its spread more to direct flight than to the assistance of wind [20]. Tortrix moths appear to follow the general rule, and fly when and where they want to, resisting the wind. If flight breaks were ever attempted they must have been doomed to failure from the start.

The statements about the spread of Tortrix by wind refer to the moth stage. It should be mentioned that the wind is sometimes responsible for blowing recently hatched caterpillars from bush to bush by means of the silk fibres spun by them. Hutson [7] remarks that they may in this way be removed three and four bushes to leeward of their starting point. The rate of spread on a large scale in this manner would, of course, be very slow. Apart from wind, they may be carried considerable distances by people working through the bushes, as when suspended by threads, the caterpillars may be easily caught on clothing.

Spraying.—A very large quantity of poisonous material is used against insect pests every year all over the world. The saving in the quantity of crop produced, and the improvement in quality, is pronounced, and regular spray programmes are part of the routine work of farms and orchards. The peculiar nature of the tea crop, however, precludes the use of virulent poisons against leaf-eating insects, so that in this particular case the utilisation of a powerful weapon is prevented. To find an ideal substance which, while killing nearly 100 per cent. of Tortrix for a reasonable outlay, is at the same time both harmless to the plant and of no effect on the made tea, is probably beyond the bounds of possibility at the present time. An effort was made some years ago [15] to use lead chromate in a spray to kill the caterpillars. In the report of this experiment issued afterwards, a large amount of space is devoted to the layout of the experiment, the manufacture of leaf plucked on different plots, and the preparation of the sprays. The effect of the sprays on the tea bushes and on the manufactured product, and of weather on the sprayed bushes is also given. The remainder of the space is devoted to the examination of samples of made tea by experts, and it seems clear that the lead chromate spray had no effect on the tea. Unfortunately, no details are recorded of the effect of the poison on the caterpillars. However, this hiatus is filled by Hutson [8], who states that in some experiments of his with this poison, it had no effect at all on Tortrix caterpillars.

Spraying is an extremely laborious business on tea estates and is not to be lightly recommended. In other parts of the world it sometimes happens that the crop is a total failure from insect ravages. In such desperate cases there would be ample justification for spending money in destroying the pests in every way possible. In the case of tea, however, although there may be a reduction of crop by Tortrix, it is never so serious as to warrant enormous sums of money being spent to eradicate the pest responsible for it. If Tortrix showed signs of destroying over ninety per cent. of the crop, then it would be necessary to adopt extensive spraying programme with arsenicals. As things stand at present, there would not appear to

be any likelihood of the pest being so destructive, so that one can try means that are simpler and cheaper, if not so effective.

Collection of eggmasses.—The collection of eggmasses has several times in the past been officially recommended, and is a form of control well-known to planters, and carried out by most. But it is a measure that must be carried out correctly to give good results. In the account of the seasonal prevalence of Tortrix given earlier, it will be seen that the August generation has been taken, quite arbitrarily, as the beginning of the annual cycle. Some time then moths emerge and lay eggs, and it is at this time that eggmasses should be collected and destroyed. The peak oviposition period of the first generation may only last a few days, and if an endeavour is made to collect thoroughly then, it would save much anxiety at a later date. It would be to the advantage of most estates to have a pest gang employed to collect eggmasses and report any sudden increases; such knowledge could also be obtained if collections were regularly recorded. As the incubation period of the egg is generally seven or eight days, it does not do a great amount of good to collect eggmasses every ten days or so, as is sometimes done. They should be collected every five days during the peak periods. If the August period can be noted, the next one will occur about two months later, and as soon as a rise in egg population is again noted or reported, an intensive collection should be instituted every five days. In the case of the August generation, probably two or three such collections would suffice. The second generation oviposition period might last a little longer and require perhaps four or five collections. The third occasion is again obtained by means of adding two months to the date of the second. The number of eggmasses laid by third generation moths will be a rough inverse measure of the thoroughness of previous collections. Although the time for collecting may be to a certain extent gauged by the calendar the appearance of male moths in the field about that time is a further index of what is to follow; for, owing to a rather shorter life-cycle than the females, their appearance anticipates by some days the rise in numbers of eggmasses deposited.

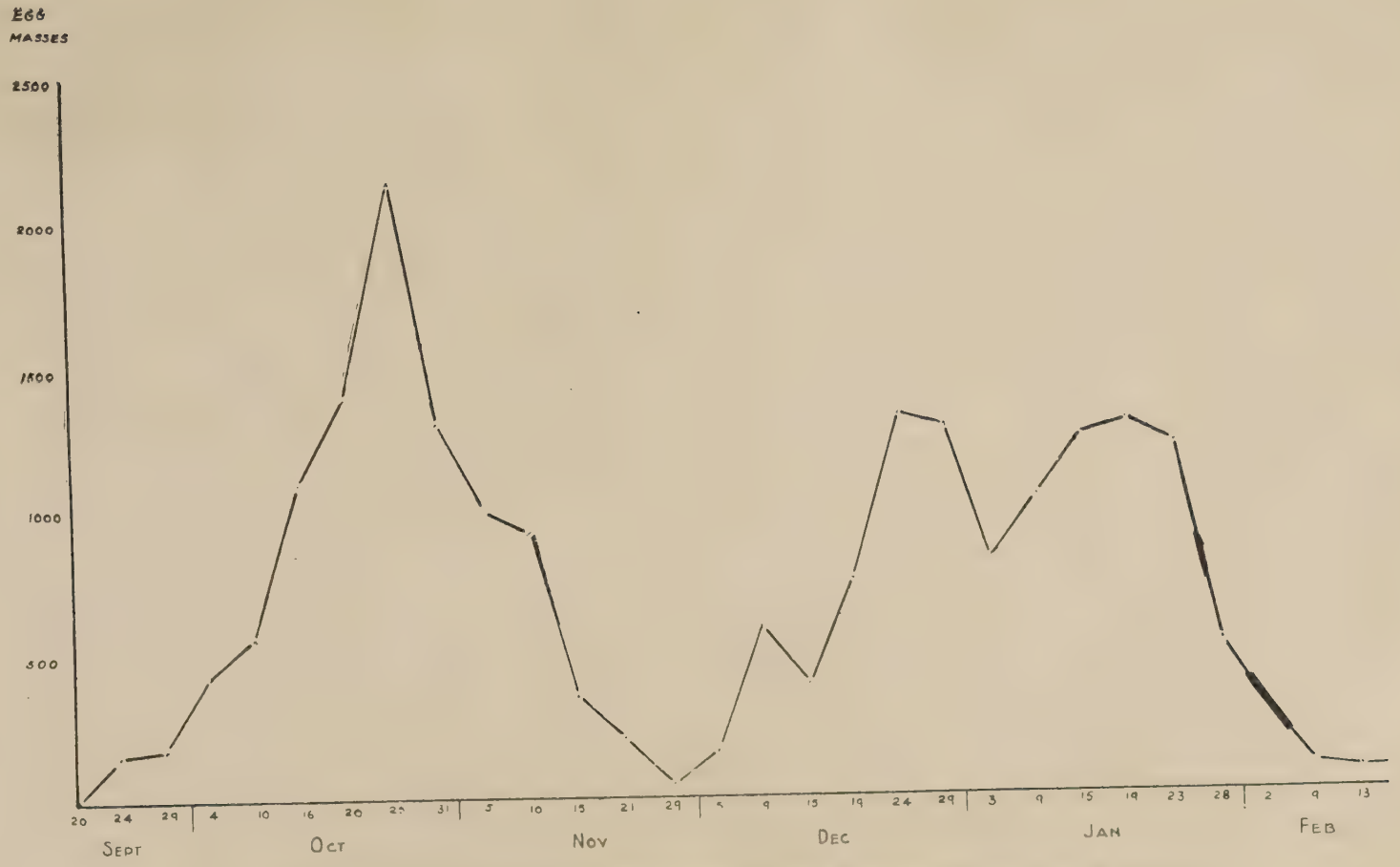


Fig. 1—Graph showing number of eggmasses of Tea Tortrix collected on a block of 4½ acres at St. Coombs.

As an instance of the value of prediction in this connection, it may be mentioned that a parasite test experiment was prepared in 1932 to begin when the third generation of moths began to oviposit. Eggmasses were collected from a small area about every five days, and the results of the collection were recorded and graphed, as shown in Figure I.

The period shown covers the second and third generations, and shows the peak period of each. The maximum of the second generation occurred during the 21st to the 25th of October, so that everything was ready just before Christmas, which, as a glance at the figure will show, was the correct time.

The intensive collection of eggmasses should be confined to the peak periods, which do not last very long, to get the maximum benefit from this form of control, and should be undertaken even if the numbers prove to be small, for one can never tell when a combination of factors favourable to the development of a much larger percentage of larvae than usually takes place may occur.

PARASITES.

Trichogramma.—The employment of parasites for control purposes may be extremely difficult owing to the fact that the large majority of them are hard to breed in captivity. An exception is provided in the case of the egg parasite, *Trichogramma*. It is a comparatively simple matter to raise very large numbers of these parasites in the laboratory. The theory of their utilisation is that they should be liberated in the field when the period of maximum oviposition is about to begin, which date can be foretold, as indicated above, so that by their natural increase afterwards they will kill at an early stage such a large percentage of individuals that the subsequent caterpillar attack will be only of a mild character; but extermination is not to be expected.

Before discussing the possibilities of success, it may be as well to draw attention to the magnitude of the problem involved in the production of large numbers of these parasites.

Let it first be assumed that the parasite will be successful in controlling Tortrix. It will be necessary to produce enough to supply about 200,000 acres of tea, which is roughly the area most subject to Tortrix. The number required per acre will be about 10,000. This is a figure worked out in 1930 as being the probable requirement, and is about the same as used in other parts of the world. One would have to cater for 1,000 eggmasses per acre at least, which means about 120,000 eggs per acre, counting 120 eggs per eggmass. Of the 10,000 parasites, about 5,000 will be females, which are capable of stinging 10 eggs apiece. It is probable, at the start, that a high proportion of parasites will fail to find eggs, but assuming that 50 per cent. do so, then 25,000 out of 120,000 will at first be killed. The next generation of parasites should produce about 13,000 females, which could dispose of 130,000 host eggs. As this generation would be due about 15-20 days after liberation (the parasites may live for a few days, and sting eggs some time after liberation), it should be capable of more effective work, owing to the increased spread. Nothing is at present known about the amount of spread, but it seems unlikely that so early the parasites will have completely covered an acre. If the first field generation is fairly successful in finding eggmasses, the second field generation should be numerous, but it is due to emerge at a time when eggmass numbers are already on the down grade.

To revert to the problem of supply. For 200,000 acres, 2,000,000,000 parasites will be required, and for this number, a similar number of host eggs will be necessary. For this purpose, it is the usual plan to utilise one of the moths which infest grain and dried products, as being easy to rear a large population. In the laboratory of the Institute, the flour moth, *Ephestia kühniella* has been found the most satisfactory, and it is reared in a mixture of bran and wheat meal. On a large scale, it is found that the maximum out-turn of moths to be expected is 10 per cent. of the eggs originally put in. Also, parasitism of eggs will not average more than about 80 per cent. As, side by side of producing *Ephestia* eggs it is necessary also to increase the number of parasites, and as a number of *Ephestia* eggs is

required to continue the propagation of these moths, we must aim at a production of about 3,000,000,000 moth eggs. The female moths lay about 100 eggs each, and a production table may be made out as follows: Starting with 50,000 eggs:—

50,000	eggs	produce	2,500	female	moths	($\frac{1}{2}$ x 10% of 50,000) which lay	250,000	eggs.
250,000	,,	,,	12,500	,,	,,	,,	$1\frac{1}{4}$	million.
$1\frac{1}{4}$	million	,,	,, say 60,000	,,	,,	,,	6	,,
6	,,	,,	,, 300,000	,,	,,	,,	30	,,
30	,,	,,	,, $1\frac{1}{2}$	million	,,	,,	150	,,
150	,,	,,	,, $7\frac{1}{2}$	,,	,,	,,	750	,,
750	,,	,,	,, $37\frac{1}{2}$	,,	,,	,,	3,750	,,

As the life cycle of this moth is about 2 months, at 70-75°F. it would take a year to produce the required number of eggs, starting with 50,000.

Allowing 6 pounds of meal per square foot, the space needed for total production would be about 20,000 sq. feet, or about half an acre of actual meal space. A fair sized building would be necessary to cope with the work, and many rooms would be required, equipped with racks to hold thousands of trays of meal. In addition, rooms would be required for breeding the parasites and for cold storage; also for storage of meal and apparatus, for dealing with large numbers of parasite cards, packing, addressing and mailing. A varied assortment of apparatus would be needed connected with the production of moths and parasites, and to deal with the whole, a numerous staff would have to be engaged.

Owing to the fact that Tortrix becomes scarce at certain times of the year, the parasite would almost die out in the field, as it does at present, so that the production as outlined above would have to be carried out every year. The annual cost of the undertaking would probably lie somewhere between Rs. 30,000 and Rs. 60,000.

Efficiency of Trichogramma in the field.—We have now to examine the probability of this parasite successfully controlling Tortrix. As remarked before, the plan initially depends on the release of the

parasite at the right time, and thereafter on the ability of the parasites to propagate in the field in the eggs provided there by Nature. The more of the latter there are, the easier it will be for the parasite to find and oviposit in them and rapidly to build up a large population.

There is little difficulty in choosing the right time; everything depends on the second proviso.

But in order to appreciate the possibilities of *Trichogramma*, it may be useful to refer to results experienced in other countries:

1. [19] In 1928 experiments were carried out in vineyards in Germany against the vine moths *Clysia ambiguella* Hb. and *Polychrosis botrana* Schiff with *Trichogramma evanescens*. The report says that although the parasites were observed to emerge normally, no noteworthy reduction was secured in the second generation of moths. This is attributed to unfavourable weather causing delayed oviposition by the moths resulting in a too scanty supply of eggs.

2. [1] *T. minutum* was released in peach orchards in New Jersey during 1930 and 1931 against the Oriental Fruit moth, *Grapholitha molesta* Busck. The rate of liberation was over 40,000 per acre at a cost of £4. In areas unprovided with parasites there was 47·7 per cent. infestation of the fruit; in the treated areas the infestation was 41·1 per cent. Such a small difference was considered not to justify the expense incurred.

3. [17] An account is given of the employment of *T. minutum* against Codling Moth in Colorado.

In "Myers" orchard, 10,000 parasites were placed on ten trees in the centre of an eight-acre block every other day throughout the season (length of season not stated) from May 29th onwards. The first parasitised eggs were found on June 16th, and the percentage parasitism is given as follows:—

July 2nd	25·45 per cent.	(after 34 days)
,, 22nd	90·83 ,,	,, 54 ,,
,, 28th	85·3 ,,	,, 60 ,,

at end of season 70·27 per cent.

In spite of the heavy parasitism towards the end of July, and of the fact that a regular spray programme was carried out as well, 85 per cent. of the fruit was, nevertheless, found to be infested by caterpillars.

In another orchard, "Kapaun", there was 46·26 per cent. parasitism at the end of the season, after liberations of parasites had been made every other day, as in the case of Myers orchard. Notwithstanding this, the crop was a total loss from Codling Moth injury.

In a third orchard, "Harvey", 500 parasites were liberated on each of twenty trees on July 13th. The spread of the parasite was observed to be even greater than in orchards where many more were liberated. Parasitism of Codling Moth eggs at the end of the season was 57·4 per cent. Result—the whole crop destroyed by Codling Moth.

In general, it is shown that a good percentage of parasitism, whether natural or induced artificially, has little effect on fruit infestation.

4. [16] In Colorado, during the five years 1928-1932, *T. minutum* was liberated for control of Codling Moth on apples, in addition to the usual spray programmes. Light parasitism was obtained in the early part of the season, developing as it progressed, sometimes up to 80 per cent. and 90 per cent. The author concludes by saying " . . . . in no case has the reduction of the Codling Moth been such that there has been a marked increase in the protection of the fruit. So, after these several years, we are forced to the conclusion that the use of the parasite does not show a great deal of promise as a solution for our difficult problem."

5. Experimenting with a species of *Trichogramma* against Codling Moth in Australia, I have received a private communication to the effect that the work was given up some time back (1930), as the indications were that the parasite would be ineffective, and the authorities would therefore afford no further grants for it.

6. [5] *Trichogramma minutum* has also been tried against the sugarcane borer, *Diatraea saccharalis*, in Louisiana, U.S.A. In 1932, fields colonised with this parasite showed much improved yields. Eggmasses were available for the insect from the beginning of June to the first week in September (about fourteen weeks), and the rate of liberation was 6,000 parasites per acre at a cost of 4/- (Rs. 2·70).

7. [2] On the other hand, when a similar experiment was carried out in Antigua on the same crop, and against the same pest in 1931 and in 1932, the conclusion was that it was ineffective.

8. [18] In Malaya, plot experiments were carried out in four different places against stem borers in paddy during the season 1931-1932. Sixteen-acre blocks, divided into sixteen plots of one acre each, were used in the experiments. Data were secured from areas of one-tenth of an acre in the centre of each plot. Eight of the plots, chosen at random, were colonised with 20,000 parasites each. Tables are given, comparing on the one hand the number of tillers damaged by borers in the colonised and control plots, and on the other hand the results of parasitism. In the first experiment, the number of tillers attacked was found to be 73·84 per cent. in the colonised plots, and 77·21 per cent. in the others, although in the latter case the number of larvae found was about double that in the former; and yields of grain were about equal. In another similar block of sixteen plots, the respective percentages of bored tillers was 71·2 per cent. and 67·5 per cent., the larvae found in the uncolonised plots being somewhat numerically superior to the others.

The second experiments show that there was a greater increase of parasitism in the colonised plots than of natural parasitism in the controls, but even so, with the great numbers employed the parasite was put down as ineffective.

The second author summarises the position by saying: "The results of investigations made during the past two years indicate that *Trichogramma* cannot be considered as an effective parasite in the control of paddy stem borers, even when liberated in large numbers."

In the literature available, there are many more references to the liberation of this parasite for control purposes. While they do not give sufficient data to warrant additions to the list made out above, it seems abundantly clear that *Trichogramma* fails to perform what is demanded of it, except possibily in the case of the sugarcane borer, *Diatraea saccharalis*. It might have been thought that, given sufficicient parasites, there should be little difficulty in them accounting for nearly 100 per cent. of the egg population; yet when small areas have been flooded with them, the result has been disappointing.

It may be pertinent at this stage to enquire just exactly what is required. The answer is that the parasite must lower the population of the pest to such an extent that the benefit derived from extra crop on that account shall more than compensate for the total cost of the operation. It is necessary that the parasite rapidly overtakes the host in point of numbers so that the chances of control are increased. In order to give it an opportunity of doing so, a large number of parasites must be liberated at a time when the host population is beginning to get numerous. That is nearly as far as we can go. The matter then entirely rests with the insect itself to propagate in the host eggs. It is possible to go a step further, and to keep liberating large numbers at frequent intervals, as in the case of the Myers orchard referred to above, but the breeding problem then assumes such vast dimensions that it is very unlikely that it would be undertaken, even if successful. There would be no justification for trying it, unlesss the annual crop was a total loss and there was a very strong probability of success. In our view, there is no likelihood of either.

We come now to the question—what is the parasite likely to do for us in the case of Tortrix on tea ? We have seen above that Codling Moth eggs are available in some numbers for at least nine weeks; the period for the sugarcane borer was similarly fourteen weeks. This period is an important matter, since the longer an abundant supply of eggs is present, the better the chances of a large parasite population; and the more parasites there are, the more

parasitized eggs there should be. Unfortunately, this is just where *Trichogramma* disagrees with our calculations; and we can do nothing about it, since the parasite must have the last word on the matter. Recurring to the period of maximum oviposition, the corresponding time for Tortrix is three to four weeks. Since the life cycle of the parasite is about 15-20 days at the time of year it would be required, the time is not sufficient for a third generation to develop itself before the number of host eggs rapidly decreases, and inevitably the number of parasites must also decline. Moreover, at the start when the parasites are liberated, a large number of eggs will infallibly be missed, since it takes time for the insects to disperse, and in addition they will not parasitise eggs more than three days old. Therefore, to answer the question set at the beginning of the paragraph, the chances of a successful campaign are not very bright.

Other Parasites.—An alternative method of attempting to deal with Tortrix on biological lines is to introduce some parasite or parasites of the larval or pupal stages which are only to be found elsewhere than Ceylon, and which give a considerable degree of control. This would necessitate a survey of some places where Tortrix is found as a minor pest of tea, and where the climate approximates to that governing the area in Ceylon which suffers most from this pest. If an opportunity arises for making an investigation in some such place as Java, it should not be allowed to pass by.

Wilt.—It has been observed by many people that at times this disease is severe among a caterpillar population. On that account proposals have occasionally been put forward to make use of it in some way in order to increase the death roll. Apart from the fact that it appears to be highly infectious, next to nothing is known about the malady, in particular how the victim becomes infected. It was supposed that if wilted caterpillars were mashed up in water, and the resulting fluid sprayed over the bushes, the insects would take the disease and die. But in order to do this, infected caterpillars must first be obtained from the field, in other words wilt must already be present, and there is no method of finding out whether the operation

of spraying the bushes will improve on the activity of the disease if left to itself. Even in small scale experiments using controls, it is not possible to discover whether apparently healthy caterpillars selected for the trials have contracted the disease before the experiment begins. Until some definite information about Wilt is forthcoming, sprays made up as suggested cannot be recommended for inclusion in contra-measures. Hutson [9] records the fact that numerous experiments over thirty years in America have failed to yield any means for increasing the natural destructiveness of Wilt.

SUMMARY.

1. Notes on the history and distribution of Tea Tortrix are given.

2. A brief account of the life-history of the pest shows that the life cycle lasts some two months. The different stages are described, and the periods of development are roughly one week for incubation, 6 weeks for the larval period, and about one week for the pupa.

3. A sketch of the seasonal history throughout the year shows that there are about five generations, that occurring in December or January being the most important.

4. Notes on natural checks, including wilt disease, parasites and birds, are given. Wilt appears to be the most important limiting factor, but none are capable, either alone or taken together, of consistently reducing the destructive power of Tortrix to reasonable limits.

5. Of the methods of artificial control, flight breaks and spraying are discussed and shown to be of doubtful value.

6. The problem of breeding *Trichogramma* and its application as a means of control are discussed in detail, and examples of the results of experiments in other parts of the world are added.

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SOME INDIGENOUS WEEDS.

C. HUNTLEY WILKINSON.

The following notes describe some of the "weeds" occurring on an estate at an elevation of 4,000 to 5,000 feet in the Dimbula district which may be found useful as cover crops.

Cardamine hirsuta. (Mustard Weed).—This was fully described by Mr. Cosens in the last issue of *The Tea Quarterly* and I agree with his conclusions. The roots are fibrous and do not impede forking.

Cardamine trichocarpa (Mustard weed).—This species has no petals in the flower, but is otherwise similar to *Cardamine hirsuta*, in which white small petals are present.

Artemisia vulgaris. (Chrysanthemum weed).—I do not advocate the establishment of this in tea.

It is not generally realised that this plant is common in the hedges grown around line gardens, where it may attain a height of four to five feet. Absinthe is obtained from a related species.

Oxalis corniculata.—This species is a creeper. It grows best in young clearings where there is not much shade.

Oxalis latifolia and *Oxalis corymbosa*.—These are introduced species and are distinguishable from *Oxalis corniculata* by their bulbous habit. It is practically impossible to eradicate them. On no occasion did any evidence of harm to the tea caused by them come before the Soil Erosion Committee.

Drymaria cordata.—Despite the valiant efforts being made to deal with this plant, and the thousands of rupees that have thereby been wasted, it is increasing its spread in the tea districts. Once it has obtained a hold it is very difficult to eradicate. It is best accepted and, if the weeder's day is not taken up with shifting soil with a karandy, he will have plenty of time to remove the *Drymaria* from around the bolls of the tea bushes once a month, with no extra cost to the estate. If treated in this way it does not get the opportunity of climbing up to the plucking table. The roots are fibrous in nature.

Ranunculus wallichianus.—This plant is to be found Up-country in damp, shady situations. With a little encouragement this makes a very efficient ground cover.

Justicia procumbens.—The same remark applies to this species.

Laurembergia wangerinii.—The same remark applies to this species.

Centella asiatica. (Violet weed).—I eradicate this species as I personally consider it forms too close a mat, unless very frequently forked.

Desmodium triflorum.—The same remark applies.

Hydrocotyle javanica.—This plant covers the ground well and as yet has shown no tendency to creep up the tea bushes.

Biophytum proliferum.—This is the best indigenous cover crop that I have to date, but I doubt whether anyone out to cover the whole estate with a cover would do it as quickly with this as with *Oxalis* or *Drymaria*; the "cover" of this species is light and feathery and, to my mind, ideal.

Rungia elatior.—This species may be safely established by the man who would like to be able to remove his ground cover at a later date, should he change his mind.

Cassia leschenaultiana.—This plant is leguminous, in distinction to the foregoing species, but is apt to grow too high.

Parochetus communis.—This species is leguminous but is rather difficult to establish; when growing well it makes an excellent cover crop.

I am not yet convinced that prolific creeping roots of a cover crop are harmful to tea if the ground is properly and often forked. I am of opinion that, provided this is done, the channels formed by the steady decay of these roots are invaluable for keeping the ground below the surface well aerated. The effect might almost be compared with that produced by a charge of dynamite—a means of achieving this object which was much discussed in Ceylon before the war.

If *Drymaria cordata* is left alone except when the land is actually forked it will be found that its creeping propensities are very greatly curtailed. If it is continually "handled" by weeders it seems to assume a much more fighting attitude. I presume that this handling has the same effect as pruning has on the tea bush.

Indigofera endecaphylla.—Though this is not indigenous, some mention should be made of it. I have already explained that I am not convinced that prolific creeping roots are harmful and this remark applies closely to the above.

In Dimbula at any rate the control of this useful ground cover is not difficult—a very little attention prevents it from creeping through the bushes and it is an easy matter to prune off the foliage and bury it under ground when forking.

THE ORIGIN AND MANAGEMENT OF TROPICAL SOILS

(REVIEW).

The student of tropical soils and their agricultural use is at a severe disadvantage in comparison with his fellow in temperate climates. He is not dealing with settled conditions of high cultivation of long standing; he is faced with a range of climatic conditions and soil forming processes which are nothing short of stupendous, and the amount of scientific data on which he can draw is on the whole small in the extreme. It is small wonder that as a result he has in the past received little help from books on tropical soils which have either been local in their application or impractical in their treatment and has often wished for a broad practical survey by one who has been closely identified with both the scientific and the practical side.

To meet this need an excellent account of tropical soils has recently been provided by Dr. H. Greene's translation of Dr. P. Vageler's "An Introduction to Tropical Soils"*. Dr. Vageler has

* An Introduction to Tropical Soils, by P. Vageler. Macmillan 15/.

had invaluable experience as agricultural chemist to the Dutch Tea Research Institute and has travelled extensively in Persia and East Africa. Soil workers are well acquainted with his monumental work on the soils of the Upper Nile and Gash. In this book the reader will find lucidly discussed the effect of parent rock and of climate on soil formation and a special emphasis is laid on vegetation in relationship to humus forming processes. As one reads through this book one is struck by the many points in which tropical soils and processes are different from those in temperate lands. The rapidity of the processes of chemical disintegration involving loss of humus, but speeding up the conversion of mineral reserves into available forms, is well brought out. Dr. Vageler gives it as his view that such reactions are tenfold more potent than in temperate regions. He lays bare the fallacy that a rich forest vegetation necessarily indicates a rich soil, such profusion being rather the result of the combined effect of climatic conditions and the extraordinary nutrient conservation which such a system entails. A luxuriant forest, the product of ages of growth, may supply only a relatively thin layer of humus soil which a comparatively few years of intensive cultivation will dissipate, leaving a raw soil which despite appearance is poverty-stricken. Of special interest to tea planters is his verdict on the use of 'indicator plants', i.e. certain species which are held to denote especial suitability of soil for agricultural purposes. He can name none which are a sound and useful guide. In relation to his extensive experience one must for instance review the common view that bracken on patna indicates specially favourable conditions.

The book is a statement of a creed rather than an exhibition of data and for that reason is the more suitable for general reading. It is intended in part for the planter, but the author has not been entirely successful in eliminating the scientific shorthand in common use amongst soil scientists. The general reader is entitled to take exception to such terms as 'Endodynamorphic' a technical term denoting a soil which owes its type more to external conditions such as climate than to internal conditions such as the parent rock from

which it is derived. Nevertheless all whose business it is to exploit the soil for agricultural purposes would do well to read carefully the chapters devoted to Soil Selection, Problems of Tropical Pedology (which being interpreted means soil science) and the Physical and Chemical aspects of choice of crops and soil management. In an essentially practical way Dr. Vageler brings to an agricultural focus the newer methods of examining the soil layer by layer, and shows how important a study of subsoil conditions is to all who deal with perennial crops.

It is hardly to be expected that in a book with so wide a scope controversial matter should be entirely absent, and it is because so much of the contents is authoritative that we cannot leave without comment views which appear to us to be somewhat perverse. Dr. Vageler speaks in a highly derogatory manner of the value of field experiments as guides to manurial practice. His views can best be appreciated by quoting a selection of his own words.

"We find more and more reason to regard field trials which were long considered the sole reliable test, as having notable defects. Apart from the fact that the field trial always produces results *post festum* i.e. one year too late, we have the constant stream of brand new methods for evaluating experimental data." . . . . . "No serious investigator now supports the first enthusiastic claims which were based on the apparent precision of figures obtained by applying the theory of probability to plot technique, nor would he guarantee his best experimental results as quantitative directions for practical manuring. In comparison with the information to be derived from statistical examination of large scale trials he would treat his researches merely as a basis for fairly sound manurial recommendations."

Speaking of heterogeneity in field plots he further says:—

"One can readily understand that in patchy districts practically every tree stands on its own particular soil, probably differing from that of neighbouring trees. Besides, since the number of plants under observation is small, differences between individual trees have

an unduly large effect and may occasionally give an entirely false impression". . . . "Observations supported by practical experience, and, in particular, data collected by research stations of the Dutch East Indies have now definitely established that statistical treatment of soil analyses provides an estimate of manurial requirement which is adequate for practical needs, although, of course, much has still to be done in clearing up this complicated problem."

It is a little difficult to judge just where Dr. Vageler stands in this matter. In one breath he damns "brand new methods" of statistical estimation as applied to field experiments and in the next he claims for large scale statistical work and for statistical treatment of soil analyses useful and positive results. There is of course always a stream of brand new methods in soil chemistry also and Dr. Vageler is not chary about putting them into use. Basic exchange phenomena in the soil and the study of soil profiles, of which the author makes constant use, emerged from the work of researchers in Holland and Russia at just the same time as workers in England were formulating improved methods of field experimentation.

Moreover, whatever disabilities field experiments suffer from on account of heterogeneity these apply equally to soil samples where "every tree stands on its own particular soil". The trouble with Dr. Vageler is that he has not grasped the fundamentals of field experimentation with the same sureness that he displays in soil research. In the first place no amount of mathematical statistics applied to field experiments can turn a bad experiment into a good one, and this being so it is unfair to condemn the application of the theory of probability to field experiments when the trouble actually lies deeper. Secondly, impeccable mathematical processes are sometimes applied to field (and chemical) data with a view to estimating errors which are actually not germane to the particular aspect studied. Rule of thumb application of statistical methods has often vitiated the interpretation of field work, and that emanating from the D. E. I. is no exception. It is a golden rule that nobody should apply statistical processes to the evaluating of an "error" figure

without understanding exactly what the practical meaning of that error figure is.

Nothing that has been said heretofore should be interpreted as minimising in any degree the usefulness of the schemes of chemical investigation which Dr. Vageler recommends. Our view has always been that the best results are obtained when these two aspects, chemical and field experimental, go hand in hand. The main argument in favour of field work is that it integrates the various factors which can be distinguished by soil analyses and puts them in their proper perspective if time and thought are given to the fundamentals of design.

One thing soil analysis cannot reveal and that is the interaction of nutrient supply and deficiency with other limiting factors, such as climate, pruning in tea, and time of application. As an example we may choose an experiment carried out in the Sudan a region where Dr. Vageler has successfully prosecuted soil researches. The experiment was concerned with the nitrogenous manuring of cotton†. Seventy-two treatments were tried involving all combinations of close, medium, and wide spacing with heavy, medium, and light irrigational water supply, at four dates of sowing with and without nitrogen. The results clearly demonstrated that when nitrogen was added, the amount of water available proved to be the important factor in enhancing its usefulness in early sown cotton, whilst closeness of spacing determined the effect of nitrogen in late plantings. These are considerations which no knowledge of the nitrogen status of the soil could meet however sound and detailed they might be, and an understanding of them is of first-rate importance in any agricultural enterprise.

Finally, in recommending this extremely interesting and suggestive book we are sure that soil scientists and all interested in tropical agriculture will feel on reading it that a special debt of gratitude is due to the translator for his very readable English rendering.

T. EDEN,

† F. G. Gregory, F. Crowther and A. R. Lambert—Empire Cotton Growing Corporation Conference on Cotton Growing Problems, 1930, 112.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 5th August, 1933, at 10 a.m.

Present.—Mr. R. G. Coombe (Chairman), Col. T. G. Jayewardene, V.D., Messrs. B. M. Selwyn, C. E. Hawes, Gordon Pyper, Jas. Forbes (Jnr.), I. L. Cameron, J. C. Kelly, D. T. Richards, A. W. L. Turner (Secretary) and by invitation Mr. G. K. Stewart, M.S.C., and Dr. C. H. Gadd (Acting Director, T. R. I.).

Absent.—The Hon'ble the Financial Secretary, the Director of Agriculture, and Mr. D. H. Kotalawala, M.S.C.

1. Notice calling the meeting was read.

2. Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 30th May, 1933, were confirmed.

3. MEMBERS OF THE BOARD T.R.I.

The Chairman welcomed:—(a) Mr. Gordon Pyper, nominated by the Planters' Association of Ceylon to act on the Board during Mr. John Horsfall's absence.

(b) Mr. C. E. Hawes, the newly-elected Chairman of the Ceylon Estates Proprietary Association.

(c) Mr. D. T. Richards, nominated by the Ceylon Estates Proprietary Association *vice* Mr. R. D. Morrison, resigned.

(d) Mr. J. C. Kelly nominated by the Ceylon Estates Proprietary Association to act on the Board during the absence of Major J. W. Oldfield.

Votes of thanks to Messrs. G. K. Stewart, M.S.C., and R. D. Morrison for services rendered were recorded.

4. SUB-COMMITTEES.

Experimental Sub-Committee.—Mr. D. T. Richards was duly elected a member of this Sub-Committee.

Finance Sub-Committee.—Mr. J. C. Kelly was elected to act on this Committee until Major Oldfield's return.

5. FINANCE.

Tea Cess and Re-organisation.—The Chairman stated that the Planters' Association of Ceylon, the Ceylon Association in London and the Ceylon Estates Proprietary Association had agreed that the Cess should be maintained at 14 cents, but the last named Association considered that the position should be reviewed at the end of 1935. The Low-Country Products Association had submitted an alternative scheme suggesting that the Cess should be 13 cents per 100 lbs. of tea during the years 1934, 1935, 1936 and 1937, 12 cents in 1938 and 10 cents thereafter.

Col. Jayewardene pointed out that the Cess paid on all tea was irrespective of the value thereof and this he considered was rather hard on the Small-Holders.

There was a general discussion with regard to Small-Holders sellling coupons and abandoning their holdings.

Mr. Gordon Pyper said that he had recently attended a meeting of Village Headmen in Kandy at which it was stated that very few, if any, villagers would abandon their holdings.

Mr. Stewart pointed out that the Small-Holdings Officer's Report indicated that there was not a great traffic in coupons because the Small-Holders were getting quite a good price for their green leaf.

Further discussion on the question of Small-Holders was postponed till later in the Meeting.

The Chairman said "With regard to the procedure to be adopted in introducing the application to the State Council, I am advised that it is necessary for a formal resolution from this Institute to be proposed stating exactly what it is we want an amended Ordinance to achieve. At the last Meeting held on the 30th May, the Report was adopted with one dissentient, Col. Jayewardene, representing

the Low-Country Products Association. It was further decided that if the proprietary interests approved of the Report, the Institute should approach the Minister for Agriculture and Lands and ask him to introduce or facilitate the introduction of a Bill in the State Council to amend Ordinance No. 12 of 1925 to give effect to our wishes.

"We have obtained the approval of the proprietary interests, it now therefore remains to implement the decision in the manner indicated. I now therefore formally move the following resolution, a copy of which is in the hands of you all:—

> "That, in order to maintain the Tea Research Institute on a sound financial basis and to support its existing activities without curtailment as detailed in the Report of the Sub-Committee of this Board, dated May 20th, 1933, the Hon'ble the Minister for Agriculture and Lands be requested to introduce or facilitate the introduction of a Bill in the State Council to amend Ordinance No. 12 of 1925 (and/or the Amending Ordinance No. 12 of 1930) to enable (a) the present Cess of 14 cents per 100 pounds of tea exported to be maintained beyond December 31st, 1933, and (b) by the deletion of Section (4) of the same Ordinance to enable such change of Headquarters to be made as may be found necessary."

This was seconded by Mr. I. L. Cameron and carried. Col. Jayewardene refrained from voting.

6. ST. COOMBS ESTATE.

(a) *The Visiting Agent's Report, dated the 26th May.*—The Chairman reported that there was a marked improvement in the cart road since a roller had been borrowed. He drew attention to the remarks under the heading of drains and expressed satisfaction that the reversible type of drainage appeared to be working so satisfactorily.

(b) *Bungalows.*—The Chairman expressed the opinion that as most of the bungalows were very damp on their S. W. sides, it would

be necessary to consider making provision in next year's estimates for smooth plastering the outside of all S. W. walls.

(c) *New Clearings.*—The Chairman stated that the bad jât bushes had all been removed and replaced with good jât plants from St. Coombs nurseries. In this connection Mr. Gordon Pyper asked if the Scientific Staff could give any information with regard to the jât which is best able to withstand shot-hole borer. It was decided that the Experimental Sub-Committee should discuss this matter.

(d) *Factory.*—The Chairman stated that in his opinion the dampness in the factory was mostly due to the abnormal weather. He added that certain drains had been deepened and new drains cut and there was already a distinct improvement. He also informed the meeting that certain recommendations made by Mr. F. J. Whitehead had been put in hand and the cost thereof would be defrayed from money voted for factory and machinery upkeep.

(e) *Testing of Plant or Systems of Manufacture at St. Coombs Factory.*—The Acting Director said that he was not yet in a position to make a statement with regard to Messrs. Brown & Co's Winnowing Machine. Experiments were being carried out and the results would be made known later. In this connection it was decided to adopt the alteration to the Rules as suggested in Circular No. A8/33, dated the 20th April, 1933. The rules are reproduced for information:—

1. On receipt of such applications, the firm or individual concerned shall be requested to give facilities to the Institute Staff to visit a factory in which such plant or process is being worked and to take such observations as may seem necessary in order to assess the scope and value of the process. Such preliminary data will, of course, be confidential and not for publication.
2. The Institute Staff will then report to the Experimental Sub-Committee who will consider the application in detail and make a recommendation to the Board as to whether the proposals should be entertained or not.

3. The Capital cost of installing any such plant shall be met by the firm or individual desiring the test to be carried out and the plant shall be removed by the firm or individual as and when requested by the Director. The firm or individual shall also bear the cost, if any, of restoring that particular part of the factory to its original condition.

4. In regard to all such work, the Institute will retain full liberty to publish in *The Tea Quarterly* or Institute Bulletins all data obtained whether favourable or otherwise.

5. In installing any such experimental plant, it would seem desirable to obtain a certificate from the firm or individual concerned that the installation as carried out meets their requirements in providing proper facilitites for an adequate trial.

7. MR. G. K. STEWART'S VISIT TO JAVA.

The Chairman said "You will agree that Mr. Stewart's letter addressed to me on his return from Java contains matters of considerable interest and value.

The first point of interest is the comparisons between the Tea Research Laboratories located at Buitenzorg and St. Coombs.

Other points of note are those relating to the experimental plots, especially Bud-grafting of Tea as well as comparison of Jâts. The last mentioned is also under investigation at St. Coombs.

Another matter of more than passing interest is the procedure adopted for providing funds for the maintenance of research in Java which will, I do not doubt, be stressed by Mr. Stewart when he is dealing with our own Institute in the State Council in connection with the maintenance of the present rate of Cess.

The next point, and to my mind one of the most important which Mr. Stewart mentions is the work being done by the "Thee Expert Bureau" in Batavia. If such a system for tasting and reporting upon samples as well as visiting estates could be adopted in Ceylon, and include comparison of prices with London, Australia, Canada,

and S. Africa, etc., by the Tea Propaganda Board in consultation with the Tea Research Institute, Ceylon would I feel, benefit greatly. I consider that this point should be closely studied by the two bodies mentioned without loss of time.

All members will, I am sure be in accord with the suggestion that one of our Scientific Officers should pay a visit to Java to study particularly the agricultural condition of the Estates as well as some of the methods in relation to manufacture. I propose taking this matter up with Dr. Norris after his return from leave and to inform you at a later meeting of his views. One point stands out very clearly in the letter and that is that if Ceylon is to hold its place in the Tea world we must, in spite of the contrary opinion held by some of our critics, redouble our efforts in research both in agricultural and manufacturing conditions with a view to maintaining and improving our quality which alone places us and will, Mr. Stewart considers from his own observations, keep us ahead of the Dutch in prices.

I look upon this as a question which we must view broad-mindedly. We have five years to concentrate on improved methods which can only be done by increased research, which again can only be effected by maintaining, even increasing if necessary, our resources, not curtailing them. We have the opportunity, are we going to lose it ?

I have on behalf of the Board already extended an expression of appreciation to Mr. Stewart for his letter and the valuable information it contains. I now propose that this appreciation be recorded in the Minutes.

Mr. Stewart thanked the Chairman for his remarks and stated that in his opinion Java was not ahead of Ceylon so far as research was concerned, but he suggested that Dr. Gadd should go over in the near future and inspect the estates in order to gain information regarding the jât of the Tea bushes and the quality of the soil. He admitted that Ceylon could not compete with Java with regard to quantity but he was convinced that every effort should be made to

maintain the quality of Ceylon Tea. He expressed the hope that the Board would in due course appoint an officer to correspond with the officer of the Tea Expert Bureau in order to keep in constant touch with buyers and advise *re* grading, etc. He suggested that perhaps the new Technologist might be able to take on this work.

8. FACTORY EXPERIMENTATION.

Mr. Stewart asked why large-scale experiments were no longer carried on at St. Coombs Factory.

The Acting Director explained that in consultation with the Staff concerned he had very carefully considered the question of experimentation on the large-scale machinery in the light of past work before placing his views before the Experimental Sub-Committee for approval. He pointed out that special machinery had been designed and installed especially for experimental work and that the fullest use should be made of these machines. The large-scale machinery would be used to verify points of importance which evolved from the small-scale trials. He also briefly outlined the importance of accurate technique in factory experimentation and the necessity for standardising the machines and operations. It was along those lines that much of the factory investigations were progressing at present.

The Chairman invited Messrs. Gordon Pyper and J. C. Kelly to attend the next Meeting of the Experimental Sub-Committee at St. Coombs at 10 a.m. on the 26th August.

9. ADVISORY WORK FOR INDIAN ESTATES.

The Acting Director's suggestion with regard to this subject was sent to each member of the Board under cover of Circular No. A. 15/33, dated the 21st June.

After a short discussion it was decided that the Rules suggested by the Acting Director should be adopted. These rules are as follows:—

1. No investigations may be undertaken for Companies or Estates outside Ceylon.

2. Opinions on data provided by an Estate or Company outside Ceylon may be given on payment of a fee.
3. If the enquiring estate or Company is not a subscriber to any appropriate Research Institution the fee should be much enhanced.
4. The scale of fees will be at the discretion of the Director. The fee should be based on the number of main questions contained in the enquiry, thus an enquiry containing two questions, on the basis of Rs. 25·00 per query, would entail a fee of Rs. 50·00.
5. The above rules do not apply to enquiries direct from Research Stations. There should be no restriction whatever on the free exchange of opinion between Research Stations.

10. COURSES OF INSTRUCTION AT ST. COOMBS.

The Chairman explained that the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association had been asked to express opinions with regard to the holding of courses of instruction at St. Coombs for Junior Members of the planting community and conferences for Senior Members. The Ceylon Estates Proprietary Association had replied that if there was a general desire by the Planters' Association of Ceylon for inaugurating these courses the suggestion would be worthy of further consideration. The Planters' Association replied that the principle of the suggestion received their approval but it was considered that the present time was not opportune for inaugurating these courses and conferences.

11. AUTOMOBILE ASSOCIATION OF CEYLON.

Announced that in accordance with the decision of the Board at its Meeting on the 14th April, 1933, the Automobile Association of Ceylon had been asked if the Institute could become a Member of that Association. A reply had been received to the effect that the Association's rules did not provide for firms, companies or institutions becoming members.

12. ANY OTHER BUSINESS.

Small-Holdings.—The Report of the Small-Holdings Officer was considered and it was agreed that Mr. Illankoon should continue to advise Small-Holders not to sell their coupons and that he should do all in his power to keep the Small-Holders out of the hands of exploiters.

Col. Jayewardene suggested that in his next report Mr. Illankoon should intimate the number present at each of his demonstration meetings.

Mr. Kotalawala's remark in his letter quoted earlier in the Minutes regarding demonstration plots was discussed and it was decided that if the Director considered the establishment of demonstration plots necessary he should again refer to the Board before taking any action.

The Meeting closed with a vote of thanks to the Chair.

A. W. L. TURNER,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Staff may not be free to show them round. Such visitors, on arrival at the Factory, are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

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OF CEYLON.

Edited by

C. H. GADD, D.Sc.,

Acting Director, Tea Research Institute.

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St. Coombs, Talawakelle.

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